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ANALYTICAL ESSAYS

TOWARDS PROMOTING

THE

CHEMICAL KNOWLEDGE

OF

MINERAL SUBSTANCES.

BY MARTIN HENRY KLAPROTH,

PROFESSOR OF CHEMISTRY, ASSESSOR TO THE ROYAL COLLEGE OF PHYSICIANS, MEMBER OF THE ROYAL ACADEMY
OF SCIENCES AT BERLIN, AND VARIOUS OTHER
LEARNED SOCIETIES.

TRANSLATED FROM THE GERMAN.

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THE merits of KLAPROTH, in Chemical Analyſis, are ſo eminently eſtabliſhed with men of ſcience throughout Europe, that it would ſeem improper to enlarge on the moſt conſummate ſkill and accuracy with which he performed his experiments, as well as on his laudable candour in ſtating their reſults.

On this conſideration, it is hoped that the tranſlation of his Analytico-chemical Eſſays, *&c. which is here offered to the patronage of the Engliſh Chemiſts, will meet with their kind approbation.—It may be neceſſary to add, that all the* Eſſays *of the Author relating to this ſubject, and which, in the German original, were publiſhed in two volumes, are, for the accommodation of the public, comprized in this ſingle Volume.*

Whenever Mr. Klaproth, *as he has given hopes to the Tranſlator, ſhall give another collection of his laſt and neweſt Eſſays, they will be immediately rendered into Engliſh.*

☞ *If ſome typographical errors, and a few other miſtakes which unfortunately have eſcaped the moſt careful attention, ſhould create ſome difficulty in the ſenſe, the reader is requeſted to refer to the errata in the laſt page.*

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PREFACE

OF

THE AUTHOR.

IT has long been my deſign to collect my *Mineralogico-chemical Eſſays*, diſperſed in various books and journals, and to publiſh them, together with ſome new Reſearches; but want of time, and other impediments, have hitherto prevented me from accompliſhing it.

Much as I wiſhed to give to my Analytical Inquiries the greateſt poſſible degree of truth and perfection, and thereby to fulfil the duties which the Chemiſt owes to the Science which he intends to promote by his writings, as well as to the Public, to whom he offers the fruits of his labour; I was, nevertheleſs, too often under the neceſſity of experiencing, how difficult it is to accompliſh this purpoſe.

Of the 26 Treatiſes contained in this *firſt Vol. of Eſſays towards a Chemical Knowledge of Mineral Subſtances**, the greater number is here publiſhed

---

* Mr. *Klaproth* here alludes to the publication of the firſt part of his Eſſays, at Berlin, 1795. The preſent volume comprehends alſo the ſecond part of them; and what is ſaid by the author, with reſpect to this laſt, has been added at the end of this Preface.—Tranſl.

for the firſt time. Each of them being unconnected with the others, I followed no particular order with them; and I alſo diſregarded the order of publication, with reſpect to thoſe that were before publiſhed ſeparately. In my operations with the genus of *ſilver-ores*, I intended, for the farther advancement of the ſyſtematical part of *Oryctognoſy*, to ſubject to analytical examination, not only particular ſpecies and varieties, but entire genuſes, with their chief ſpecies. But I was ſoon convinced, that the execution of this deſign was impracticable, both on account of the few leiſure hours which I could command, and as, in general, it ſurpaſſes the powers of an individual.

Having merely in view the progreſs of Natural Science, founded on *pure experience*, that is to ſay, on plain facts, free from all hypotheſis, I entertain, on preſenting theſe labours to the Public, the moſt ardent deſire of ſeeing the words of *Bergmann**, "*Aliorum tentamina, preſertim cardinalia, candide ſunt revidenda,*" put into practice; for, as this philoſophical Chemiſt very properly adds: "*Plus vident oculi, quam oculus; ideoque, quæ nova exhibentur, pluribus teſtibus in diverſis locis utiliter confirmari puto.*"—Being thoroughly convinced of my own fallibility, I recommend this examination with the greater eagerneſs, ſince the reſults of ſeveral of my experiments, reſpecting the conſtituent parts of foſſils, are, frequently, in ſtriking contradiction to thoſe given by others. Thus the mineralogical world may be informed, on which ſide truth ſtands, or the leaſt error occurs; and the *Oryctologiſt* may, with greater certainty than before could be done, apply the data given him to the perfection of his art. On my part, I ſhall always receive with pleaſure any well grounded correction of my labours, and better information.

---

* De Indagando Vero.

With reſpect to thoſe, who may poſſeſs patience and inclination ſufficient to undertake a repetition of my experiments, I have deſcribed every particular management, as circumſtantially as could be done, conſiſtently with keeping within due bounds that prolixity which is hardly ever ſeparable from the narrative of chemical proceſſes. Thoſe who are familiar with this ſubject, will perceive my endeavours to reduce the analyſis of mineral bodies to methods which are ſimple in themſelves, and lead to reſults that may be depended on. Among others, I flatter myſelf with having traced out a way of analyſing *gems*, which ſeems to deſerve being followed by ſkilful Chemiſts.

A circumſtance, ſeemingly indifferent, often produces in chemical experiments, as in other inveſtigations, unexpected conſequences; which may be proved by comparing my former with my later analytical experiments, made with the *Adamantine Spar*, and *Circon* (Jargon of Ceylon), which, on this account, I have placed next to each other in the reſpective Treatiſes. Who, for example, would have imagined, that the application of cauſtic alkali in the *liquid* ſtate ſhould ſo exceedingly facilitate the opening of hard ſtony matter, and remove the greateſt part of the difficulties with which I had to ſtruggle, when employing the ſame ſeparating medium in the *dry* ſtate?

As many perſons think that the preparation of a perfectly pure cauſtic lye is ſubject to more difficulties than it really is, I will here briefly ſtate my method of preparing it.—I boil equal parts of purified ſalt of tartar, (carbonat of potaſh, or vegetable alkali prepared from tartar) and Carrara marble, burnt to lime, with a ſufficient quantity of water, in a poliſhed iron kettle; I ſtrain the lye through clean linen, and, though yet turbid, reduce it by boiling, till it contain about one half of its weight of cauſtic alkali; after which I paſs it once more through a linen-cloth, and ſet it by in a glaſs bottle. After ſome days, when the lye has become clear of itſelf, by ſtanding, I carefully pour it off from the ſediment into another bottle. To convince myſelf of its purity, I ſaturate part of it with muriatic or nitric acid, evaporate it to dryneſs, and re-diſſolve it in water.

If it be pure, no turbidneſs will take place in the ſolution. The quantity of cauſtic alkali, which this lye contains, I aſcertain by evaporating a certain weighed portion of the lye to dryneſs, in an evaporating diſh of a known weight. I alſo take care, in the preparation of this cauſtic lye, that the alkali be not entirely deprived of carbonic acid; becauſe, in that caſe, I can, with greater certainty, depend on the total abſence of diſſolved calcareous earth. By employing burnt marble, or, in its ſtead, burnt oyſter-ſhells, I avoid the uſual contamination of the cauſtic lye by aluminous earth; becauſe lime, prepared from the common ſpecies of lime-ſtone, is ſeldom entirely free from argil.

Beſides, the choice of the veſſels requires great care. Since even the beſt porcelain is attacked and diſſolved by cauſtic alkali, I employ ſilver, reduced from muriat of ſilver, (Horn-ſilver), for veſſels appropriated to fuſion. This material, however, notwithſtanding its other advantages, is not abſolutely free from all inconvenience. For, if the crucible made of its has not been prepared with every poſſible care, ſmall ſcales will detach from it, which mingle with the body to be examined, and frequently occaſion illuſive appearances. Having already found, unexpectedly, that even a crucible made of platina would not, as had been wiſhed, reſiſt the action of ignited cauſtic alkali; I imagine that a crucible made of pure maſſive gold would be the moſt eligible. On this account, Profeſſor *Storr* ſeems to be in the right, when he concludes his *Propoſals, reſpecting the examination of the mixture of gems*[*], with the following words: "The difficulties occurring in this operation will the ſooner diſappear, if a great amateur of gems ſhould chooſe to ſpend the value of ſome thouſand ducats for their examination." Meanwhile, I flatter myſelf with having in ſome manner counteracted thoſe difficulties; though I was not encouraged by ſuch a high premium.

Though for the moſt part I have followed the *new nomenclature*, I have not ſcrupulouſly confined myſelf to its terms; but have, for the ſake of brevity, now and then uſed the denominations, *Glauber's-ſalt*, *Common-ſalt*, *Horn-ſilver*, *Blood-lye*, &c. as alſo the term *mild*, in ſtead of carbonated, in oppoſition to *cauſtic*[†]. Speaking of water, to avoid too frequent repetitions, I have moſtly omitted to particularize it as *diſtilled.* Thus, alſo, I have not in every ſingle inſtance mentioned the *edulcoration* of the precipitates, or reſidues; this and ſimilar operations being always underſtood to have been performed.

---

[*] *Crell's* Chemiſches Journal, vol. VI. 1781. page 227.

[†] The Tranſlator, however, has, for the moſt part, preferred the *new nomenclature*, and frequently added the former denominations, for reaſons not neceſſary to be particularly mentioned.—Tranſl.

Concerning

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Concerning the Second Part.[*]

I HERE offer to the chemical and mineralogical public the *ſecond* volume of my *Eſſays*, &c. animated by the hope, that it will meet the ſame encouraging approbation with which the *firſt* has been honoured by ſcientific men, whoſe deciſion in this branch of the Knowledge of Nature commands reſpect.

The numbers of the Eſſays, contained in this volume, proceed in a continued ſeries with thoſe of the preceding. Of thoſe now given (1797), only a few have been before printed in various publications, and are here merely collected.—All the others are entirely new, and, at preſent, publiſhed for the firſt time.

As theſe eſſays were the fruit of my leiſure hours only, ſeveral of them have not arrived at that degree of perfection, to which, perhaps, they might have approached, if the uſual avocations of my duties had permitted me to perform them with greater convenience and opportunity.

---

[*] This is the Preface to Mr. *Klaproth's* ſecond volume of the German Edition; and the words, PART I. and PART II. have been deſignedly inſerted in the following Table of CONTENTS; the better to diſtinguiſh the firſt 26 Eſſays belonging to the firſt volume from the remaining eſſays, publiſhed in the ſecond volume of the original.

In this reſpect I earneſtly wiſh, that, for the advancement of the ſcience, the *chemico-analytical reſearches* publiſhed in this ſecond volume may ſhare the ſame good fortune with thoſe of the firſt:—I mean to ſay, that they may be examined, corrected, and farther purſued by expert Chemiſts.

M. H. KLAPROTH.

CONTENTS.

CONTENTS.

PART I.

Page

I. EXPERIMENTS concerning the Habitudes of various Species of *Stones* and *Earths* in the Heat of a *Porcelain-furnace* 1

II. Analyſis of the *black-grey Flint* 39

III. Experiments on the *Adamantine Spar*
- *Firſt Section* 43
- *Second Section* 59
  - A. Adamantine Spar, from *China* 60
  - B. ——————— *Bengal* 64

IV. Examination of the *Oriental Sapphire* 71

V. Examination of the *Cat's-eye* 78
  - A. From *Ceylon* 79
  - B. ——— the Coaſt of *Malabar* 82

VI. Analyſis of *Chryſoberyl* 85

VII. Examination of *Chryſolite* 91

VIII. Examination of *Olivin* 99
- *Firſt Section.* Olivin, from *Unckel* 100
- *Second Section.* ——————— *Karlsberg* 105

IX. Examination of various Silver-ores 109
- *Firſt Section. Native Hornſilver* 111
  - A. *Maſſive*, from *Saxony* 115
  - B. Corneous Silver-ore, from *Schlangenberg* . . 119
  - C. *Argillo-muriated* Silver-ore . . . . . . ib.
  - D. Of *Juſti's* ſuppoſed *alkaline* Silver-ore . . . 121
- *Second Section. Red Silver-ore* 124
  - A. From *Andreasberg*, in the *Upper Harz* . . . 127
  - B. ——— *Freiberg*, in *Saxony* 134
- *Third Section.* Vitreous Silver-ore 137
  - A. From *Freiberg* 138
  - B. ——— *Joachimſthal*, in *Bohemia* 139
- *Fourth Section. Brittle vitreous* Silver-ore 140
- *Fifth Section. White* Silver-ore 143
  - A. *Light-ditto*, from *Erbiſdorf*, near *Freiberg* . . 145
  - B. *Dark-ditto*, from *Freiberg* 149
- *Sixth Section.* Grey Silver-ore, from *Kremnitz* . . 152
- *Seventh Section.* Native Amalgam of Silver . . . 156
- *Eighth Section.* Arſenical Silver, from *Andreasberg* . 158

X. Examination of the Oriental Lapis Lazuli 163

XI.

Page
XI. Examination of the Smalt-blue Foſſil, from *Vorau*, in *Auſtria* 170
XII. Examination of the Jargon of Ceylon (*Circon*)
Firſt Section 175
Second Section 188
XIII. Examination of Hyacinth 195
XIV. Examination of the *ſuppoſed* Hungarian Red Shörl 200
XV. Examination of a new Foſſil, from Paſſau . . . 211
XVI. Examination of the *ſuppoſed* Molybdenous Silver . 218
XVII. Examination of the Native Alumine, from *Schemnitz* 221
XVIII. Chemical Reſearches into Strontianite compared with Witherite 223
XIX. Examination of Lepidolite 238
XX. Examination of Cimolite 248
XXI. Examination of the Magneſian Spar
A. From Tyrol 256
B. From *Taberg*, in *Sweden* 259
XXII. Examination of the *ſuppoſed* Muriacite 262
XXIII. Examination of the Native Alum, from *Miſeno* . 266
XXIV. Examination of the Native Nitre, from Molfetta . 270
XXV. Examination of the Mineral Springs at *Carlsbad*, in *Bohemia* 274
XXVI. Examination of the Saline Springs at *Königsborn*, and their Products 298

PART II.

XXVII. EXAMINATION of Spinell 316
XXVIII. Examination of the Emerald, from *Peru* . . . 325
XXIX. Examination of the Bohemian Garnet 329
XXX. Examination of the Oriental Garnet 334
XXXI. Examination of Veſuvian
Firſt Section. Veſuvian, from *Veſuvius* . . . 338
Second Section. ——————— *Siberia* 342
XXXII. Examination of Leucite
Firſt Section. Leucite, from *Veſuvius* 348
Second Section. The ſame continued 352
Third Section. Leucite, from *Albano* 361
Fourth Section. ——— in *irregular* maſſes . . . 363
Fifth Section. ——— acted on by *volcanic fire*
1. From *Pompeji* 364
2. ——— *Ronciglione* 365

XXXIV.

Page

XXXIII. Examination of Pumice-ſtone, from Lipari . . . 368

XXXIV. Examination of the Terra Auſtralis *(Sidneia)* . 371

XXXV. Examination of the granular Sulphat of Barytes, from *Peggau* 375

XXXVI. Examination of the teſtaceous Sulphat of Barytes, from Freiberg 378

XXXVII. Examination of Staurolite *(Croſs-ſtone)* . . . 384

XXXVIII. Farther Reſearches into Witherite and Strontianite

Firſt Section 387

Second Section 390

XXXIX. Examination of the Sulphat of Strontian, from *Penſylvania* 394

XL. Examination of the Water of the Boiling Spring, at *Rykum*, in *Iceland* 399

XLI. Examination of the ſiliceous Tufa *(Kieſeltuff)* from the *Geyſer*, in *Iceland* 406

XLII. Examination of the Elaſtic Quarz, from *Braſil* . 409

XLIII. Examination of the Hyalite (Glaſs-ſtone), from Dauphiny 413

XLIV. Examination of Chryſopraſe, and its concomitant *green* Earth

Firſt Section. Analyſis of Chryſopraſe . . . 420

Second Section. Analyſis of the green Earth of Chryſopraſe 425

XLV. Examination of the Noble Opal, from *Cſcherwenitza*, in *Upper Hungary* 440

XLVI. Examination of the *Hydrophanes*, from *Saxony* . 443

XLVII. Examination of the White and Green Opal, from *Koſemütz*, in *Sileſia* 445

XLVIII. Examination of the Yellow Opal, from *Telkebanya*, in *Upper-Hungary* 447

XLIX. Examination of the *Brown-red Semi-opal*, from *Telkebanya*, in *Hungary* 449

L. Examination of *Menilite*, from *Menil-montant*, near *Paris* 451

LI. Examination of *Werner's Poliſhing-ſlate*, from *Menil-montant*, near *Paris* 455

LII. Examination of *Silici-murite* (Meerſchaum), from the *Levant* 456

LIII. Examination of the *Semi-indurated Steatites*, from *Bareuth*, in *Franconia* 460

LIV. Examination of *Steatites* (Soap-rock), from *Cornwall* 462

LV. Examination of the *Chineſe Agalmatolite* (Plaſtic-ſtone) 465

LVI.

		Page
LVI.	Second Examination of *Lepidolite* (page 238) . .	471
LVII.	Examination of *Uranite*	476
LVIII.	Examination of *two* newly diſcovered *Titanites*, from *Spain*, and *Aſchaffenburg*, in *Germany* . .	496
LIX.	Examination of ſome *ferruginous Titanites*, from *Cornwall*	499
LX.	Examination of the *Garnet-ſhaped Ore of Manganeſe*, from the *Speſſart*	510
LXI.	Examination of the *Native Oxyd of Tin* (Tin-ſtone)	515
LXII.	Examination of the *Native Sulphuret of Tin* (Tin-pyrites), from *Cornwall*	525
LXIII.	Examination of the *Molybdat of Lead*, from *Bleiberg*, in Carinthia	532
LXIV.	Examination of the *Sulphuret of Copper* (vitreous Copper-ore, Kupfer-glanz), from *Siberia* . . .	541
LXV.	Examination of the *variegated Copper-ores* (Bunt-kupfererz) from *Hitterdahl*, in Norway, and *Rudelſtadt*, in Sileſia	545
LXVI.	Examination of the *Siberian Malachites*	550
LXVII.	Examination of the *Biſmuthic Silver-ore*, from *Schapbach*, in Suabia	554
LXVIII.	Examination of the *Antimoniated Silver*, from *Wolfach*, in Suabia	560
LXIX.	Examination of the *cryſtallized, bright, white, Cobalt-ore* (Glanz-kobalt), from *Tunaberg*, in Sweden	564
LXX.	Examination of the *Cobaltic Ore of Manganeſe*, from *Rengersdorf*, in Luſatia	569
LXXI.	Examination of the *Native Sulphat of Cobalt* (Kobalt-vitriol) from *Herrengrund*, in Hungary . .	579
LXXII.	Examination of the *Mineral Springs* at *Imnau*, in Suabia	580

I.

EXPERIMENTS
ON THE
HABITUDES OF VARIOUS SPECIES
OF
STONES AND EARTHS
IN THE
FIRE OF A PORCELAIN-FURNACE.

A SCIENTIFIC enquiry into that claſs of natural bodies, which belong to the *mineral kingdom*, includes a number of particulars, which it is neceſſary to unite, in order to obtain a complete knowledge of the ſubject.

Theſe are:

1. Their *geognoſtic* ſituation*: and
2. Their *external characteriſtic marks:* which both together conſtitute their *natural hiſtory.*
3. The experiments relating to the *phyſical properties* and powers of bodies in an undecompoſed ſtate. Such are: their ſpecific gravity, elaſticity, magnetic attraction, the phenomena exhibited by them with regard to light, and the like.
4. Their habitudes or changes in the *fire*; and
5. Their *chemical conſtituent parts.*

---

* *Werner*, who introduced the expreſſion *Geognoſy*, underſtands by it a general acquaintance with the ſolid parts of our globe, the various ſituations or beds of foſſils, and their reciprocal relations to each other. Thus he diſtinguiſhes geognoſy from *mineralogical geography*, which only treats of the native places of foſſils.—Tranſl.

As

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As to the *habitudes of minerals in fire*, they indeed belong to the *chemical* part of natural ſcience; but ſo far only, as their conſtituent parts, or their proportions to each other, are made to ſuffer an alteration by this agent. Therefore, the phenomena, which take place on warming or heating, without producing a laſting change in the chemical mixture of the conſtituent parts, do not belong to this, but to its *phyſical* part. Thus, for inſtance, the power of attracting and repelling light bodies, excited in *Tourmaline* by warming it, ſhould only be reckoned among its phyſical properties; but, on the contrary, the phoſphoreſcence of the *Fluor-ſpar* and the *Apatite*, though but moderately heated, already effect ſome alteration in the natural chemical proportion of their conſtituent parts.

Though ſeveral induſtrious naturaliſts have examined various ſpecies of earths and ſtones merely by fire, few of them, however, have furniſhed *ſimple facts* or *experiments*. Some, as *Pott* and *Gellert*, according to their particular purpoſes, have directed their attention more to the products of fuſion, in compoſitions of their own making, than to the mere habitudes of the ſimple foſſils. Others, *D'Arcet* for inſtance, have indeed had regard to this laſt circumſtance; but they have miſſed their end, at leaſt for the greateſt part, by expoſing the body under trial to fire in immediate contact with argillaceous crucibles. For, the reſults could not fail to be falſe in moſt caſes, on account of the aluminous earth from the corroded maſs of the crucible mingling with the ſubſtance of the experiment.

So far as I know, Mr. *Gerhard*[*] is the only chemiſt, who, in his valuable experiments concerning the habitudes

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[*] *Gerhard's Verſuch einer Geſchichte des Mineralreichs*, 2 Vol. Berlin, 1781-82.—Vol. II. § 2. page 1—44.

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tudes of foſſils in the fire, has paid due attention to the nature of the veſſels; and has communicated true reſults, becauſe in his operations he employed crucibles of charcoal, beſides thoſe manufactured of clay and chalk.

The reſults of my experiments on the effects produced by fire on various ſpecies of ſtones and earths, which I am now about to give, may ſerve to confirm ſeveral, and in ſome reſpects be conſidered as a continuation of thoſe of *Gerhard*.

When ſpeaking of the experiments on fuſion made by the above mentioned naturaliſts, as well as of my own, the mere action of *common* fire in wind and porcelain-furnaces is underſtood. Hence, neither dioptrical and catoptrical experiments belong to this inveſtigation; nor thoſe, which ſeveral philoſophers have made by ſtrengthening the fire by means of oxygen gas. For, howſoever valuable the latter are in other reſpects, I am inclined to think, that in a mineralogical view, the action of violent ignition ſuſtained by oxygen gas is not a convenient method for aſcertaining the relative habitudes of minerals in the fire.

To be enabled to draw juſt concluſions from experiments of this kind, it is neceſſary that they be all performed with the moſt equal degree of heat. This advantage was afforded to me by the furnaces of the Royal Porcelain-manufactory (at Berlin); into which the foſſils, ready prepared for this trial, were put; together with the porcelain, ſubjected to final baking.

For experiments to be performed in charcoal crucibles, a cavity was made in a thick fragment of well-burned charcoal, of a volume anſwering the ſize of the foſſil. This being put in, the cavity was cloſed with a charcoal ſtopper;

after which the charcoal-crucible was fitted into another crucible made of baked clay, and this laſt well joined with its cover by luting.

In order to make comparative experiments, I placed another quantity of each foſſil immediately in a crucible made of clay unmixed with iron. After the cover had been luted on, it was expoſed to the ſame intenſity of heat.

In every caſe where the loſs of weight could be aſcertained with ſome degree of certainty, I have always mentioned it.

No. I. ADULARIA; from Mount St. *Gottbard.*

a) In the *charcoal-crucible**, a colourleſs glaſs, clear in its ſubſtance, but quite full of very ſmall froth-bubbles. On this account it appears of a greyiſh-white, and exhibits no vitreous ſplintery fracture, but a minute conchoidal, with very fine pores.

b) In the *clay-crucible.* The ſame.

No. 2. White ALABASTER.

a) CH. Cr. was rendered moderately hard, white paſſing into ſtraw-yellow, in ſome places finely ſtreaked, of a fine-grained earthy fracture, adhering to the tongue, and emitting an odour like that of alkaline ſulphuret.—Loſs of weight, 0,56.

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* For the ſake of brevity, the *Charcoal-crucible* is marked CH. Cr. and the *Clay-crucible*, CL. Cr.

In the ſame manner L. of W. means *loſs of weight.*

b) CL. Cr. A black-brown glaſs, very ſhining, little tranſparent on the edges, with ſeparate bubbles.

No. 3. AMIANTHUS; from *Greenland.*

a) CH. Cr. A roundiſh fuſed ſcoria, of a dirty pearl grey, externally covered with ſome ſmall grains of iron. Fracture, dull, finely porous, with diſperſed inlaid gloſſy particles.

b) CL. Cr. Has run into a greeniſh, opake ſcoria, of a fracture almoſt dull. The whole ſurface covered with cryſtals of a greeniſh and light brown colour, in the form of delicate needles, of a reticular form.

No. 4. ASBESTUS, mountain green: (Berg-holz) from *Siberia.*

a) CH. Cr. Unaltered as to form, ſimply hardened by ignition. Its ſurface inveſted with a thin reddiſh cruſt; the edges blackiſh, and overlaid with fine exſuded grains of iron.—L. of W. 0,16.

b) CL. Cr. The form likewiſe unchanged; of a light brown colour, rendered very hard, and covered with ſome ferruginous ſpots.

No. 5. ASBESTUS; from *Taberg.*

a) CH. Cr. A light-grey ſlag, fuſed into a ſphere, and covered with grains of iron, of a glittering ſurface, and having detached, ſhining, large bubble-holes.—L. of W. 0,25.

N. 6. BASALT; aſh-grey, coarſe-grained (Swed. *Trap*; and, according to *Werner*, Grünſtein;) from *Hunneberg*, in Weſtgothland.

a) CH. Cr. Fuſed into a compact glaſs, of a clove-brown colour, tranſparent in ſplinters, of a large conchoidal fracture. Externally, partly glazed brown, partly inveſted with a ferruginous cruſt, and large grains of iron. —L. of W. 0,06.

b) A ſolid black glaſs, covered with a brown, ſteel-grey, veined iron-cruſt.

No. 7. BASALT, denſe, columnar; from the *Haſenberge*, in the middle mountains of Bohemia.

a) CH. Cr. Externally, a compact grey maſs, richly over-laid with pretty large grains of iron, and in part alſo covered with a tombac-brown ferruginous cruſt. Its fracture of a bright aſh-grey, and to appearance dull and earthy; but if examined with a lens, poſſeſſed of a texture very finely porous, and ſpongy throughout; and very rough to the feel.—L. of W. 0,09.

b) CL. Cr. A black denſe glaſs, tranſparent, and of a clove-brown, in thin ſplinters, of an even or groſs-conchoidal fracture. At the top, it exhibits a light-brown, gloſſy, and delicately-flowered cruſt.

No. 8. BASALT, denſe, columnar; from *Stolpe*, in Saxony.

a) CH. Cr. A compact maſs, inveſted at the top with a blackiſh grey glazing, but, on the ſides and underneath, with numerous grains of iron, and in part covered with a tombac-brown iron-cruſt. In fracture, aſh-grey, dull, denſe, ſomewhat ſplintery, in ſome places of a ſpongy texture hardly diſtinguiſhable, and in others exhibiting clove-brown gloſſy veins.—L. of W. 0,08.

Note 1. Another, but ſmaller quantity of the ſame baſalt, treated in the ſame manner, I found, had the ſame external appearances; but its internal colour was white-grey; its texture was more denſe, and traverſed by minute, blackiſh vitreous veins.

Note 2. I put the ſpecimen of No. 8. *a*) a ſecond time into the charcoal crucible, after having ſeparated the iron-grains. It appeared afterwards of an amorphous, and on the upper part confuſedly fibrous form; but its fracture preſented a darkiſh grey, compact, fine-grained, untranſparent, highly glittering, and, towards the ſides, greaſy gloſſy ſcoria.

b) CL. Cr. As No. 7. *b*).

No. 9. BASALT, largely perforated, with interſperſed, ſingle, ſmall grains of olivin; from the iſland of *Skye*.

a) CH. Cr. On the ſurface overlaid with many grains of iron, of a conſiderable ſize. Fracture dark aſh-grey, very rugged, dull, and earthy; but, viewed by a lens, ſpongy, with fine pores.—L. of W. 0,08.

Note. The grains of iron being ſeparated, this maſs was again placed in a freſh CH. Cr. Its ſurface then aſſumed the figure of vermicularly twiſted branches, lying flat; ſome of which had a copper-red metallic luſtre. Its fracture like No. 8, note 2.

b) CL. Cr. The ſame as No. 7. *b)*

No. 10. BASALT, porphyraceous; from the new *Cammeni*, near *Santorini*.

Note. The principal black maſs was a medium between ſiliceous ſhiſtus, *(Kieſelſchieſer)* jaſper, and baſalt; with diſſeminated tender, white, vitreous ſquares and grains.

a) CH. Cr. Melted into a ſolid, blackiſh glaſs; whoſe fragments were of a yellowiſh-green, and tranſparent. It was covered with a ſteel-grey ferruginous cruſt, and of a gloſſy, large conchoidal fracture.—L. of W. 0,02.

b) CL. Cr. A compact, black glaſs; but its ſplinters clove-brown and tranſparent. Fracture of the large, and, in ſome degree, ſmooth conchoidal form. Surface inveſted with a bright brown, ſhining pellicle.

No. 11. LIGNIFORM ASBESTUS (Bergholz), brown; from *Tyrol.*

a) CH. Cr. Suffered no alteration of form; burned hard, and aſſumed a greeniſh-brown ſurface, with a red and white inveſtment. Its edges foliated in lamellæ, blackiſh, and garniſhed with extremely delicate exſuded grains of iron. Fracture bright, ſteel-grey, and glittering.—L. of W. 0,39.

b) CL. Cr. Coaleſcing by fuſion with the parts of the crucibles that were in contact with the fragments. Their external ſurfaces exhibited a texture, conſiſting of brown, reſplendent, implicated, ſhort ſtriæ. The fracture dark-grey, little ſhining, and of bright-grey rays and points, as it were interwoven, with ſome air-bubbles.

No. 12. BERYL, yellow; from *Siberia.*

a) CH. Cr. No change in the figure. Colour dirty pale-bluiſh-grey, with a greaſy luſtre, and a little tranſparent. Fracture uneven, groſs-ſplintery.—L. of W. 0,01.

b) CL. Cr. The ſame.

No. 13. BERYL, ſea-green; alſo from *Siberia.*

a) CH. Cr. In general of leſs ſplendour; but the lateral ſurfaces of the column covered all over with fine, ſhining, needle-formed radii. In other reſpects, as No. 12. *a*)

b) CL. Cr. Like No. 12. *b*)

No. 14. SHORLITE (*Schörlartiger Beryl*); from *Altenberg.*

a) CH. Cr. Unaltered as to form; indurated by the ignition; became grey, dull, and rough; with minute glittering points of a nearly metallic luſtre.—L. of W. 0,25.

b) CL. Cr. The ſame phenomena; but without ſhining points.

No.

No. 15. PUMICE-STONE, common; from *Lipari.*

a) CH. Cr. A bluiſh-black-grey, denſe glaſs, with ſome air-bubbles; ſemi-tranſlucid when reduced to thin fragments; and externally overlaid with a few grains of iron. L. of W. 0,10.

b) CL. Cr. Afforded a clearly fuſed, light-blackiſh-green, glaſſy ſubſtance, of almoſt colourleſs and clear ſplinters, with ſome air-bubbles.

No. 16. COMPOUND SPAR (*Bitterſpath*); from *Zillerthal*, in *Tyrol.*

a) CH. Cr. Fell into ſmall yellowiſh-grey, and yellowiſh-brown, friable, and in part diſtinctly rhomboidal pieces, of an earthy appearance.—L. of W. 0,45.

b) CL. Cr. On the upper part it run into a clear, bright graſs-green glaſs, of a ſmooth ſurface; but on the lower part into a light-grey frothy ſcoria.

No. 17. BOLE, red armenian; *genuine.*

Note. Conſiſts of a red, friable lithomarga (*Steinmark*), with white ſpeckles.

a) CH. Cr. Burned hard, was glittering, and of an iron-black colour.—L. of W. 0,20.

b) CL. Cr. Hardened by burning; partly ſteel-grey, partly dirty-brown; having the ſurface covered with tranſuded and re-calcined or oxyded ferruginous particles; rough and porous.

No. 18. BOLE, red armenian; *common.*

a) Melted into an ill-ſhaped hollow globe, whoſe outward and inward ſurfaces were of a dim ſteel-grey colour, and inlaid with reſplendent grains of iron. Its fracture preſented a black-grey slag, ſhining, and in part porous.—L. of W. 0,16.

b) CL. Cr. Gave a brown ſcoria; gloſſy like pitch; full of large bubbles; of an uneven ſurface, reſembling the ſpecular or grey iron-ore (*eiſen-glänziz*).

No. 19. BORACITE; from *Lüneburg*.

a) CH. Cr. Each cryſtal fell ſeparately into a globular form; acquired a cavity in the middle, and preſented here and there incumbent, very tender ferruginous grains. Fracture whitiſh-grey, ſhining, uneven, and foliated; in part alſo ſtriated.

b) CL. Cr. Produced a yellowiſh, clear glaſs, containing ſome air-bubbles; and having ſeparate, ſmall, dim-white ſpots.

No. 20. SIDERO-CALCITE (*Braunſpath*), in lumps*, grey-white; from *Freyberg*.

a) CH. Cr. Fell into black-brown, cracked and friable lumps, entirely reſembling perfectly decayed ſidero-calcite, and ſhewed exceedingly minute, tranſuded metallic grains.

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* In German *derbe*, the preciſe meaning of which expreſſion *Kirwan* aſſerts, (Elem. of Mineral. I. p 26) he could never learn. According to *Emmerling*, any ſolid foſſil is called *derbe* which is concreted or imbedded in another, and is of the ſize of a *hazel-nut*, and above, to any magnitude; whereas that which is called in German *cingeſprengt* (diſſeminated, interſperſed) is under the ſize of a hazel-nut, to any minuteneſs obſervable. As the ſize of the foſſils treated of in this work is ſeldom determined, the word *derbe* will be given in this tranſlation by the expreſſions *in lumps*, *in maſſes*, and ſometimes *maſſive*.—Tranſl.

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b) CL. Cr. Changed into a glaſs of a dark black-brown colour, tranſparent on the edges, and pellucid in ſmall fragments.

No. 21. CORNELIAN, oriental.

a) CH. Cr. No change in its form, very fragile, of a ſnowy-white from the outer edge, almoſt to the thickneſs of $\frac{1}{12}$ inch; but internally very pale reddiſh white. The fracture of the white border was conchoidal and reſplendent; that of the inner parts earthy and dull.—It ſuffered no loſs of weight.

b) CL. Cr. Throughout of a ſnow-white, partly ſpotted, ſomewhat greyiſh, and preſerving its external ſplendour.

No. 22. CHALCEDONY; from *Ferröe.*

a) CH. Cr. Of unaltered ſhape; white as ſnow; eaſy to be broken; externally, and in the fracture, glittering.—L. of W. 0,01.

b) CL. Cr. The ſame.

No. 23. CHLORITE, looſe, from the cavity of a rock-cryſtal; from *St. Gotthard.*

a) CH. Cr. A contracted, black, ſhining, ſomewhat radiated maſs, ſimilar to a brittle pit-coal.

b) CL. Cr. Fuſed into a ſolid, black-brown, vitreous ſubſtance.

No. 24. CHRYSOBERYL, from *Braſil.*

a) CH. Cr. Remained totally unchanged, except that its ſurface became a little rougher.

b) CL. Cr. Likewiſe unaltered; only its colour turned ſomewhat paler, and the external ſurface acquired ſpots of a dull white.

No.

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No. 25. CHRYSOLITE, oriental.

a) CH. Cr. Its ſurface covered with a thick ferruginous cruſt, of a reddiſh-brown, paſſing into ſteel-grey, and glittering. Its original green colour was no longer perceivable in the fracture. Its form, ſplendour, and tranſparency, quite unaltered.

b) CL. Cr. No change as to form, tranſparency, and luſtre; but the colour inclined now to olive-green.

No. 26. CHRYSOPRASE; from *Koſemütz.*

a) CH. Cr. Had its figure unaltered, turned very light blackiſh-grey, of a ſtrong gloſs, and perfectly opake. In the ſtreak it exhibited a kind of metallic luſtre.—L. of W. 0,01.

b) CL. Cr. The ſame effect.

No. 27. CIMOLITE; from the iſland of *Cimolo* (Cimolia Plinii).

a) CH. Cr. A black-grey, moderately ſhining, ſcummy ſlag, of little weight.—L. of W. 0,25.

b) CL. Cr. A yellowiſh-white, half fuſed, hard, ſmall frothy ſcoria, reſembling corroded quarz.

No. 28. CYANITE, cryſtallized; from *St. Gotthard.*

a) CH. Cr. Burned white, was ſplit, became very friable, and internally ſhining.—No loſs of weight.

b) CL. Cr. The ſame.

No. 29. CYANITE, common; from the ſame place.

a) CH. Cr. Was rendered aſh-grey by ignition, and ſplit, in the manner of wood.—No loſs of weight.

b) CL. Cr. Snowy-white, and ſplit.

No. 30. FEL-SPAR ? compact, blue; from *Krieglach*

a) CH. Cr. Furniſhed a grey-white glaſs, ſcummy in the fracture, and thereby divided into ſhapeleſs cellules, like fine tabular quarz. It preſented detached ferruginous grains, and ſhewed alſo on the ſurface a number of fine ſplendid ſpeckles.—L. of W. 0,40.

b) CL. Cr. Shrunk into milky-white, irregular, rough lumps, with a diſtinctly beginning vitrification.

No. 31. FEL-SPAR, common, red; from *Lommitz*.

a) CH. Cr. As No. 1. *a*)
b) CL. Cr. As No. 1. *a*)

No. 32. FEL-SPAR, vitreous, in hexagonal plates; from the *Porphyry* of *Drachenfels*.

a) CH. Cr. A greyiſh-white glaſs, almoſt pellucid; of a ſtrong gloſs on the fracture, and having air-bubbles.—L. of W. 0,02.

b) CL. Cr. A ſemi-pellucid, bright-grey, ſomewhat frothed glaſs; in ſome places ſpeckled blackiſh or browniſh.

No. 33. FEL-SPAR, green; from *Siberia*.

a) CH. Cr. Like No. 32. *a*)

b) CL. Cr. Produced a milk-white glaſs, of a fine froth, but clear in ſmall pieces.

No. 34. FLUOR-SPAR, yellow, cubic; from *Gerſdorf*.

a) CH. Cr. A milky-white ſcoria; fuſed on the outſide; in the fracture lamellar, of reſplendent planes.—L. of W. 0,04.

b) CL. Cr. Fuſed into a clear, bright graſs-green glaſs.

No. 35. SPECULAR GYPSUM (*Frauenеis, glacies Mariæ.*)

a) CH. Cr. Rendered white, very friable; and its lamellæ ſpecular or reflecting light.—L. of W. 0,60.

b) CL. Cr. Clove-brown glaſs, with large ſpherical air-bubbles.

No. 36. HYALITE, or Glaſs-ſtone, (VIOLET SHOERL); cryſtallized; from *Dauphiny*.

a) CH. Cr. A ſemi-pellucid greyiſh-white glaſs, o brilliant, flat conchoidal fracture; outwardly ſpread over with ferruginous grains.—L. of W. 0,12.

b) CL. Cr. A denſe, ſemi-pellucid, deep clove-brown.

No. 37. HYALITE (*Violet Shörl*), in maſſes; from *Thum* (*Thumerſtone*).

a) CH. Cr. As No. 36. *a*).—L. of W. 0,10.
b) CL. Cr. As No. 36. *b*).

No. 38. MICA, grey, groſs-foliated; from *Cornwall*.

a) CH. Cr. A greeniſh-grey, ſemi-pellucid glaſs, overlaid with minute grains of iron.—L. of W. 0,10.

b) CL. Cr. Run into a compact, blackiſh, opake glaſs; of a ſmooth, ſtrongly-ſhining ſurface, and conchoidal fracture.

No. 39. GARNET, red, bohemian.

a) CH. Cr. Afforded a grey, turbid glaſs; full of grains of iron.

b) CL. Cr. Fuſed into an opake, almoſt compact ſcoria, whoſe colour internally changed by ſtripes from brown into green; very finely corroded.

No. 40. GARNET, oriental.

a) CH. Cr. The ſame change as No. 39. *a*).

b) CL. Cr. Yielded a compact black glaſs; of a bright luſtre; covered with a ſteel-grey cruſt.

No. 41. GRANATITE, (till now ſo called); from St. *Gotthard.*

a) CH. Cr. Became hard; ſteel-grey; overlaid with ſmall ferruginous grains.

b) CL. Cr. Rendered hard; of an iron black colour; with ſhining points of a metallic luſtre.

No. 42, GREEN EARTH; from *Cyprus.*

a) CH. Cr. Fuſed into an irregular ſphere; which had externally a dirty green colour, and preſented in the fracture a ſomewhat porous maſs, compoſed of an emerald-green glaſs and a pale-green ſcoria. Here and there it was croſſed partly by white metallic lamellæ, partly by reguline copper. There was alſo found, in one of its cavities, a variegated copper-ore in ſmall grains.—L. of W. 0,17.

b) CL. Cr. Exhibited a fuſed compact ſcoria; in the fracture of which the upper part was brown and reſplendent; the lower one greeniſh grey, and glittering. At top it ſhewed grey-white, delicate plumoſe traces, of a luſtre nearly metallic, upon a brown ground.

No. 43. HELIOTROPIUM, oriental.

a) The figure unaltered; but rendered a little ſofter by the ignition. The colour changed from dull-greeniſh to a grey-white. Its fracture uneven, ſplintery, rough and glittering. The red points, which had diſappeared, left ſmall holes behind them.—L. of W. 0,01.

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b) CL. Cr. The colour turned throughout whitiſh grey. In other reſpects as at *a*).

No. 44. HORN-BLENDE, baſaltic; from the crater of *Veſuvius*.

a) CH. Cr. A hardened, ill-ſhaped maſs, with grains of iron. Fracture light-grey, uneven, faintly glittering; without any trace of vitrification.—L. of W. 0,10.

b) CL. Cr. Melted into a denſe, black-brown glaſs; tranſparent in thin fragments; of a ſmooth ſurface, and a flat conchoidal, gloſſy fracture.

No. 45. HORN BLENDE, common; from *Neurode*, in the county of *Glatz*, in Bohemia.

a) CH. Cr. An indurated maſs; on the outſide wrinkled, of a colour verging into copper-red, inlaid with many granular particles of iron. Internally light pearly-grey, uneven, ſlightly glittering; here and there with a beginning vitrification.—L. of W. 0,06.

b) CL. Cr. As No. 44. *b*).

No. 46. HORNBLENDE? common; from *Nora*, in Weſtmanland.

a) CH. Cr. Run into an imperfect, greeniſh-black vitreous ſubſtance, tranſparent on the edges, overlaid with an iron black, rugoſe or ſhrivelled cruſt. Fracture, with air-bubbles, of a copper-colour.—L. of W. 0,14.

b) CL. Cr. A compact ſcoria, whoſe colour, from below upwards, changed from leek-green to greeniſh black. Covered with a ſteel-grey metallic cruſt. Fracture, moderately ſhining, of a greaſy luſtre.

No. 47. HYACINTH; from *Ceylon.*

a) CH. Cr. Its colour became greyiſh-white. The cryſtals in ſome degree coaleſced; but remained in other reſpects unchanged, except their tranſparency being diminiſhed..—No. L. of W.

b) CL. Cr. Such of the cryſtals as were in contact with the crucible, united with it by fuſion, throwing up a ferruginous cruſt. The others were looſely conglutinated together. The colour, in part, paſſed into a wine-yellow.

No. 48. CAT'S-EYES, grey-white; from *Ceylon.*

a) CH. Cr. Became ſoft, grey, dimmed, and opake by the action of the fire.—No. L. of W.

b) CL. Cr. The ſame change.

No. 49. CAT'S-EYE, red; from *Malabar.*

a) CH. Cr. Like No. 48. *a*)

b) CL. Cr. The ſame.

No. 50. LABRADOR-HORNBLENDE *(Labrador-)* *ſtein).*

a) CH. Cr. Fuſed into a compact glaſs, of great luſtre, pellucid in ſmall ſplinters, of a pale-grey colour, with very minute, detached grains of iron.—L. of W. 0,04.

b) CL. Cr. A compact, duſky-white ſcoria, tranſparent on the edges.

No. 51. LAPIS LAZULI, deep-blue.

a) CH. Cr. A denſe, grey, ſemi-pellucid glaſs; overlaid with grains of iron.—L. of W. 0,12.

b) CL. Cr. A denſe, browniſh, black glaſs, with ſeparate grains of iron upon its ſurface.

No. 52. LAVA, looſe, frothy; from *Veſuvius.*

a) CH. Cr. Changed to a compact glaſs, of a greeniſh-grey tinge, containing granular particles of iron; and tranſparent on the edges.—L. of W. 0,08.

b) CL. Cr. A compact, browniſh-black glaſs, having ruſty ſpots on the upper part.

No. 53. LEMNIAN EARTH, common. (Bole).

a) CH. Cr. A denſe, deep-greeniſh-grey glaſs, covered with a cruſt coloured like ruſt of iron, and ſome ferruginous grains.—L. of W. 0,25.

b) CL. Cr. A compact greeniſh-black glaſs; ſhewing at the top light-brown points, lying flat.

No. 54. LEPIDOLITE (Lilalite); from *Roſna* in Moravia.

a) CH. Cr. Produced a pale-grey, denſe, ſemi-pellucid, very hard glaſs; partially covered with a grey ferruginous cruſt.—L. of W. 0,17.

b) CL. Cr. Afforded a greyiſh-white, tranſparent glaſs, with very ſmall bubbles; and on the upper parts covered with a light-brown cruſt, of a luſtre nearly metallic.

No. 55. LEUCITE (not yet affected by volcanic fire); from *Veſuvius.*

a) CH. Cr. Outwardly a commencement of fuſion; the inſide little altered, and ſtill very gloſſy. The hornblende which it contained within, was melted into ſeparate, black, minute drops.

b) CL. Cr. Exactly the ſame.

No. 56. MARBLE, white; from *Carrara.*

a) CH. Cr. Was converted into quicklime.

b) CL. Cr. Changed into a denſe, clear, hard, pale graſs-green glaſs.

No. 57. PLASTIC SILICI-MURITE (*Meerschaum, Keffekil* of Cronſtedt); from the *Levant.*

a) CH. Cr. Not altered; only rendered more meagre and indurated by ignition; very ſtrongly adhering to the tongue.—L. of W. 0,30.

b) CL. Cr. The ſame.

No. 58. OBSIDIAN, black; from Mount *Hecla* in Iceland.

a) CH. Cr. A greeniſh-black glaſs, of great ſplendour; pellucid in ſmall pieces, outwardly with a grey incruſtation.

b) CL. Cr. Melted into a denſe, black-brown glaſs; tranſparent only in its ſmalleſt ſplinters, and of a conchoidal fracture.

No. 59. OBSIDIAN, blackiſh-grey, tranſparent; from *Lipari.*

a) CH. Cr. Gave a glaſs, pellucid in larger lumps; of a ſomewhat duſky, pale, graſs-green hue, containing air-bubbles, and externally covered with a grey turbid cruſt.

b) CL. Cr. Fuſed into a clear, pale-black-greeniſh glaſs, with ſeparate bubble-holes.

No. 60. OBSIDIAN; from *Tokay.*

a) CH. Cr. Like No. 59. *a*)

b) CL. Cr. Like No. 59. *b*)

No. 61. OLIVIN; from *Greenland.*

a) CH. Cr. The grains black, opake, finely glazed, and conglutinated.

b) CL. Cr. Almoſt the ſame change, and coaleſced with the ſides of the crucible, which it powerfully attacked.

No. 62. OLIVIN; from *Habichtſwalde.*

(*a* CH. Cr. As No. 61. *a*); only a little more firmly coaleſced.

b) CL. Cr. As No. 61. *b*)

No. 63. OLIVIN; from *Ritterſdorff,* in the middle mountains of Bohemia.

a) CH. Cr. The concretion of the grains ſtronger; alſo ſtrongly glazed, and of a dirty leek-green.

b) CL.

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b) CL. Cr. Like No. 61. *b*)

No. 64. OLIVIN; from *Unkel*.

a) CH. Cr. Its grains were covered with a greeniſh-black glaze, cemented together, and croſſed by a white maſs, in ſome places cryſtallized in a delicate capillary form. Their outer ſides were inveſted with grains of iron.—L. of W. 0,02.

b) CL. Cr. Were fuſed into one gloſſy, ſomewhat porous maſs, which, in the upper part, was cryſtallized in a radiated form, with a browniſh-grey tinge; but in the fracture it was partly greeniſh-white, partly graſs-green.

No. 65. OPAL (ſemi-opal), brown-red; from the *Telkebanya* mountains.

a) CH. Cr. Without alteration as to form. Externally black-grey, dull, and in every part covered with diſſeminated ſmall grains of iron. In the fracture, browniſh-grey, dull, and uneven.—L. of W. 0,18.

b) CL. Cr. Little changed in the form. Externally reſembling the ſpecular or grey iron-ore (*Eiſenglanz*). Its fracture black, glittering, and in a ſmall degree porous.

No. 66. OPAL (ſemi-opal), yellow; from the ſame place.

a) CH. Cr. Figure unaltered; its colour turned greyiſh-white, and it was much diſpoſed to fly in pieces. Some luſtre on the outſide; in the fracture, dull and earthy, of a fine grain.—L. of W. 0,06.

b) CL. Cr. The ſame changes; together with a ſomewhat brighter luſtre.

No. 67. OPAL, *ſemi-opal of a verdigris-colour (Heliotropium?)*; from Greenland.

a) CH. Cr. Was rendered ſoft, its fracture of a light-reddiſh-brown, ſpeckled with a copper-red; glittering, and exhibiting dim-white points and veins.

b) CL. Cr. Rendered not quite ſo ſoft by the ignition; and it acquired a liver-colour, with white ſpots.—L. of W. 0,06.

No. 68. PITCH-STONE, yellow; from *Meiſſen.*

a) CH. Cr. A greyiſh-white glaſs; though clear in itſelf, yet full of froth-bubbles. The outer ſurface preſented a deep-grey, ſhining cruſt.

b) CL. Cr. The ſame; but without the external incruſtation.

No. 69. PITCH-STONE, blue (ſo ſtyled); from *Menil-Montant*, near Paris.

a) CH. Cr. Became ſoft, yellowiſh-white, and ſplit or cleft in the manner of ſlate.

b) CL. Cr. The ſame changes; except its colour turning light-brown.—L. of W. 0,08.

No. 70. SHISTOSE PORPHYRY; from *Schloſsberg* near *Töplitz*. (Its chief maſs the *Klingſtein*, as it is called).

a) CH. Cr. Run into a denſe, very ſhining glaſs, of a grey tinge inclining to deep-green; tranſparent in ſmall fragments, and inlaid with detached, nearly tin-white grains of iron.—L. of W 0,05.

b) CL. Cr. A compact browniſh-black glaſs, with tranſparent edges, and a conchoidal fracture.

No. 71. PORCELAIN JASPER, yellow; from Bohemia.

a) CH. Cr. Suffered no alteration in its form; but was rendered ſomewhat contracted, of a deep ſteel-grey, and dull.

b) CL. Cr. Figure unchanged; externally yellowiſh-brown; in the fracture, black and glittering.

No. 72. PRASE; from *Breitenbrunn.*

a) CH. Cr. Its form unaltered; externally of a grey-white, ſhining, inlaid with tranſuded grains of iron. Its fracture, greeniſh-white, of a faint luſtre, and uneven. Totally opake.—L. of W. 0,03.

b) CL. Cr. The form likewiſe unaltered; externally of a ſmutty-greeniſh white, gloſſy, and ſpotted with minute drops reſembling pitch. Fracture grey and dim.

No. 73. QUARZ, red; from *Rabenſtein.*

a) CH. Cr. No change in the figure; colour entirely pale reddiſh-white; ſlightly tranſparent; and inveſted with a delicate glazing.—L. of W. 0,03.

b) CL. Cr. The ſame.

No. 74. RUBY, roſe-red, *oriental.*

a) CH. Cr. No alteration; except its ſurface having become a little dimmed.—Alſo without L. of W.

b) CL. Cr. Entirely unchanged. Its colour even ſeemed to be rendered ſtill purer and more lively than before ignition.

No. 75. MUSCOVY GLASS (*Gliſt*, *Mica*); from *Siberia.*

a) CH. Cr. In order to incloſe it in the crucible, ſeveral lamellas were rolled up. The outer ones became grey, glazed and brittle; the inner ones black, like tinder, and continued flexible.—No. L. of W.

b) CL. Cr. Every one of the lamellas thoroughly hardened by the ignition, glazed, brittle, rendered nearly ſonorous. Colour changed to a greyiſh-white; the ſurface in part alſo light-brown.—No. L. of W.

No. 76. SAPPHIRE, azure-blue; from *Ceylon.*

a) CH. Cr. Without alteration; except the ſurface, which became a little duſky, and dim and muddy.—No loſs of weight.

b) CL. Cr. Likewiſe unaltered. However, the colour was rendered in ſome pieces paler, and at the ſame time ſlightly opaleſcent.

No. 77. PRISMATIC SHOERL, black, longitudinally ſtreaked; from *Cornwall.*

a) CH. Cr. Little change in the figure. Outwardly, ſtill preſerving, in part, the priſmatic form, with grains of iron exuded. Fracture grey, of but little gloſs, reſembling that of fat.—L. of W. 0,09.

b) CL. Cr. Imperfectly fuſed; on the upper part brown, with glittering points. Fracture of a blackiſh-grey, ſlightly reſplendent, with a greaſy luſtre, and exhibiting fine pores.

No. 78. SHOERL, black cryſtallized, in columns of nine ſides; from St. *Gotthard.*

a) CH. Cr. Externally aſh-grey, and very much ſhrivelled. In the fracture preſenting a compact, ſmoke-grey, moderately ſhining ſcoria; with ſeveral large bubbles, containing on the inſide diſſeminated granular particles of iron.—L. of W. 0,08.

b) CL. Cr. Fuſed into a tough, pale, olive-green ſlag, of a moderate gloſs like fat; with ſeveral large air-bubbles.

No. 79. SHOERL, black, in large hexagonal columns; from *Greenland.*

a) CH. C. Converted into a ſcoria of a greeniſh-grey tinge, and tranſparent fragments. Its ſurface was coated with a duſky cruſt, and ſcattered grains of iron.—L. of W. 0,07.

b) CL. Cr. An olive-green ſlag, tranſparent in thin ſplinters, of conſiderable compactneſs, and a wrinkled ſurface.

No. 80. SERPENTINE, blackiſh; from *Zöblitz.*

a) CH.

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a) CH. Cr. Indurated; externally covered with a ferruginous cruſt, together with ſmall grains of iron. In the fracture, ſplintery, dull and of a grey colour.—L. of W. 0,12.

b) CL. Cr. Rendered hard. The ſurface glittering, glazed in part, and paſſing from iron-black to a copper-red. Towards the edges of the fracture likewiſe iron-black, but in the middle of a pale greeniſh-grey; ſmooth and dull.

No. 81. EMERALD; from *Peru*.

a) CH. Cr. Entered into an imperfect fuſion, and preſerved its green colour, though ſomewhat fouled. It alſo was rendered opake, and preſented detached minute grains of iron.

b) CL. Cr. A clear, greeniſh-white glaſs, with a few radiating points.

No. 82. EMERALD? oriental; (perhaps green ſapphire?)

a) CH. Cr. Quite unaltered in ſhape. The colour was rendered ſomewhat duller, and verging towards grey. The ſurface partially covered with a rough cruſt; ſome pieces reflected changeable variegated colours.

b) CL. Cr. Figure and luſtre as before. Turned opake. The green colour in part paſſed to a white, and in ſome pieces the variegated reflection of colours was ſtill more diſtinct.

No. 83. SPINELL (Ruby).

a) CH. Cr. Suffered no change, excepting that its ſurface became ſomewhat muddy and foul.—No loſs of weight

b) CL. Cr. Part of it was imperfectly melted to a blackiſh-brown ſcoria, into which were cemented the other pieces, whoſe colour and tranſparency were unimpaired.

No. 84. ACTYNOLITE (Strahlſtein) common, green; from St. *Gotthard.*

a) CH. Cr. Externally covered with a ferruginous cruſt, and numerous grains of iron. The inſide ſhewed a grey and dull ſcoria, full of bubbles.—L. of W. 0,04.

b) CL. Cr. Converted into a fibrous ſlag, of a greeniſh-grey fracture, and a brown ſurface, cryſtallized in a radiated form.

No. 85. ACTYNOLITE, common, leek-green; from *Peterſburg*. (Swed. *Hornblenda*).

a) CH. Cr. Like No. 84. *a*); only with but few grains of iron in the ſurface, and with acicular cryſtals in the froth bubbles.—L. of W. 0,04.

b) CL. Cr. A leek-green, and at the top red-brown, compact ſcoria; of a fine ſtriated fracture, and efflorefcent cryſtallization.

No. 86. ACTYNOLITE, common, in ſeparate parallel priſms; from *Carinthia.*

a) CH. Cr. A dull, bluiſh-grey ſcoria, full of bubbles and its ſurface inlaid with grains of iron.—L. of W. 0,04.

b) CL. Cr. A denſe, greeniſh-white, and in the fracture indiſtinctly radiated flag. On the upper ſurface cryſtallized in interwoven, reticular, fine, brown needles.

No. 87. GLASSY ACTYNOLITE; needle-ſhaped, of an intermediate colour between deep mountain-green, and black-green; from *Taberg.*

a) CH. Cr. As No. 86, *a*). Its cruſt had in ſome places a cupreous luſtre.—L. of W. 0.12.

b) CL. Cr. Fuſed into a denſe, greyiſh-white, opake ſcoria, marbled of a brown-yellow at its top.

No. 88. GLASSY ACTYNOLITE, acicular, white; from *Taberg.*

a) CH. Cr. A greyiſh-white maſs, fuſed in a ſpherical form; on the upper part with ſeparate, recumbent, ſhining radiations; on the under part mixed with grains of iron. Fracture uneven, dull and rough; in parts ſtriated.—L. of W. 0,20.

b) CL. Cr. A greeniſh-white, denſe ſcoria, with a glittering greeniſh-yellow very fine efflorefcent ſurface of ſmall ſtellular points, Fracture finely fibrous and reſplendent.

No. 89. ACTYNOLITE, olive-green, in priſmatic cryſtals; from *Dauphiné.*

a) CH. Cr. The pieces did not fuſe together, but were merely conglutinated firmly. External ſurface, iron-black, with ſmall ferruginous grains, oozed through. Inſide ſteel-grey, fine earthy, and dull.—L. of W. 0,15.

b) CL. Cr. Melted into a highly reſplendent glaſs; of a black-brown colour; flat conchoidal fracture, and tranſparent ſplinters.

No. 90. ACTYNOLITE, cryſtallized in priſms, deep blackiſh-green; from *Zillerthal* in Tyrol.

a) CH. Cr. Fuſed into a ſpherical, moderately ſplendid, opake ſcoria, of a bright greeniſh-grey colour, and perfectly radiated fracture, ſurrounded with grains of iron.—L. of W. 0,06.

b) CL. Cr. A ſtrongly reſplendent, compact, opake ſlag, internally almoſt apple-green; of a conchoidal fracture, and yellow ſurface, mixed with brown.

No. 91. STRONTIANITE.

a) CH. Cr. Form unaltered. Hardened by ignition; rendered dull, and very cauſtic.—L. of W. 0,31.

b) CL. Cr. A clear, bright graſs-green glaſs.

No. 92. TALC (of the *magneſian* or *muriatic* genus); greeniſh-white; from St. *Gotthard.*

a) CH. Cr. Became hard; ſplit like ſlate; grey white; in two places ſlightly united with the crucible by fuſion.

b) CL. Cr. Rendered yellowiſh-white; hardened by the ignition, and acquiring ſlaty rifts.—L. of W. 0,05.

No. 93. TALC, Venetian.

a) CH. Cr. Indurated, ſlaty, bluiſh-grey; in part with a thin red covering.—L. of W. 0,08.

b) CL. Cr. The ſame change. Its colour brown, reſembling decayed mica.

No. 94. TOPAZ; from *Braſil.*

a) CH. Cr. Rendered white, dull, untranſparent; of a fine earthy and longitudinally ſtriated fracture.—L. of W. 0,20.

b) CL. Cr. The ſame; with thin flakes, burſt off.

No. 95. TOPAZ; from *Schneckenſtein.*

a) CH. Cr. As No. 94, *a*).—L. of W. 0,20.

b) CL. Cr. As No. 94. *b*).—L. of W. 0,20.

No. 96. TREMOLITE, radiated; from St. *Gotthard.*

a) CH. Cr. Ran into an opake, grey-white, round ſcoria; of a foliated texture, and a radiated cryſtalline ſurface.—L. of W. 0,05.

b) CL. Cr. A compact, greeniſh-white flag, with little luſtre, and of a radiated fracture.

No. 97. TRIPOLI; from *Menil-Montant*, (the matrix of what is called *blue pitch-ſtone.*)

a) CH. Cr. An indurated, very contracted, black-grey, finely porous ſcoria.

b) CL. Cr. Its outer ſurface browniſh and glittering; its internal ſurface, or fracture, yellowiſh-grey, dull, and porous like ſponge.—L. of W. 0,20.

No. 98. TOURMALINE, green, tranſparent; from *Braſil.*

a) CH. Cr. Hardened by the ignition. The ſides compreſſed inwards. Externally black-brown; internally greeniſh-grey, opake and dull.—L. of W. 0,10.

b) CL. Cr. The ſame change; but of a blacker tinge. The part of the crucible, in contact with it, covered with a brown glaze.

No. 99. TOURMALINE, black; from *Spain.*

a) CH. Cr. Hardened, and the cryſtals conglutinated. Outſide black, with croſs rifts and dull; inſide dim grey-white. Fracture, conchoidal. Slight gloſs of the greaſy kind.—L. of W. 0,15.

b) CL. Cr. Externally the ſame. The fracture, of a ſteel-grey, but with rather leſs luſtre, and with fine pores.

No. 100. TOURMALINE, black; from *Zillerthal.*

a) CH. Cr. Aſſumed a very irregular ſhape. Externally like No. 99, *a*); inwardly, of a conchoidal fracture, a ſmoky grey colour, and greaſy luſtre.

b) CL. Cr. Tough; diffuſed by melting; light-brown, opake, and of a middling greaſy luſtre.

No. 101. UMBER, (brown iron-ochre); from the neighbourhood of *Cologne.*

a) CH. Cr. Gave a denſe, opaline glaſs; of a bluiſh-grey in the fracture, tranſparent when in ſmall ſplinters, and of a ſtrong greaſy luſtre. It was coated with a grey-white cruſt, finely dotted by very minute froth-bubbles. At the bottom was one conſiderable grain of iron, which ſeparated of itſelf.—L. of W. 0,33.

b) CL. Cr. Fuſed into a ſolid, black glaſs; whoſe upper part was covered with a cruſt of the ſpecular iron, ore, (*Eiſenglanz*) very delicately effloreſcent, and radiated in a ſtellular form.

No. 102. UMBER; from *Cyprus*.

a) CH. Cr. Like No. 101, *a*) except that its cruſt was ſtill more minutely dotted, and the inward colour of a clear ſmoke-grey.—L. of W. 0,33.

b) CL. Cr. Like No. 101. *b*)

No. 103. VESUVIAN, light-brown.

a) CH. Cr. A denſe, clear, ſtrongly reſplendent, nearly colourleſs glaſs. The outer ſurface was rather muddy, and was formed into groups of regular cryſtals (*druſigt*) exhibiting very minute ſhort protuberances, each of which ended in a point, by means of four triangular, exceedingly fine ſtriated facets. Numerous grains of iron were imbedded in its under ſurface.—L. of W. 0,25.

b. CL. Cr. A compact, very dark olive-green glaſs; of a bright luſtre, and flat conchoidal fracture.

No. 104. VOLCANIC aſhes; (from the eruption of Mount Veſuvius, collected at *Naples* in the ſummer of 1794.)

a) CH. Cr. Melted into a compact glaſs, of a dirty olive-green; ſmall fragments of which tranſmitted light. It contained ſome pieces of iron.—L. of W. 0,10.

b) CL. Cr. A denſe, browniſh-black glaſs.

No. 105. WACKE (a variety of baſalt, commonly ranked among the ſpecies of argillaceous earths); from *Joachimsthal.*

a) CH. Cr As No. 7. *b*).

Note. The ſame ſpecimen was again put into the charcoal-crucible, after it had been ſeparated from the grains of iron. When taken out, it was tuberous or knobby. The ſurface preſented a glittering black-brown incruſtation, whoſe fracture had a ſlight luſtre. But the interiour maſs had become pale-grey, and denſer than before.

b) CL. Cr. The ſame change as No. 7. *b*)

No. 106. FULLER'S EARTH (*Smectis*) genuine; from *Hampſhire.*

a) CH. Cr. A compact opake ſcoria of a dull grey, with many grains of iron.—L. of W. 0,25.

b) CL. Cr. A denſe, blackiſh-green ſcoria. Its ſmooth ſurface exhibiting red dots.

No. 107. WITHERITE; from *Anglezark.*

a) CH. Cr. In experiments repeatedly made with this ſubſtance, the inner charcoal-crucible was found conſumed for the greateſt part. Hence the witherite always entered into an imperfect fuſion with the contiguous part of the clay-crucible, which ſerved as a caſe to the charcoal-crucible.

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b) CL. Cr. A green, ſomewhat turbid, and frothy glaſs.

No. 108. ZEOLITE, compact, ſiliceous, (*Prehnite*); from *Scotland.*

a) CH. Cr. Fuſed into a compact, deep-grey, opake ſcoria. Fracture, imperfectly conchoidal, and highly glittering. Coated with a ferruginous cruſt; and containing a few minute grains of iron.—L. of W. 0,05.

b) CL. Cr. An opake denſe ſlag. Its ſurface olive-green; the inner maſs, celadon-green, and the fracture glittering.

No. 109. ZEOLITE, radiated; from *Ferroë.*

a) CH. Cr. Swelled up into an ill-ſhaped, greyiſh-white, tranſparent ſcoria; full of froth bubbles.—L. of W. 0,16.

b) CL. Cr. The ſame; but as white as ſnow.

No. 110. ZEOLITE, volcanic grey; (according to *Fichtel*—according to others, zeolitic pitch-ſtone) from the Mount *Pap-Laſſo*, near *Telkebanya.*

a) CH. Cr. A glaſs of a dim, black-grey colour; of a clear tranſparence on the edges; of a greaſy gloſs in the fracture; and ſhewing ſeparate bubbles. It alſo had very ſmall grains of iron in ſeveral parts of its external ſurface.—L. of W. 0,05.

b) CL. Cr. Yielded a denſe, bright greyiſh-white, tranſparent, but not thoroughly clear glaſs; rendered turbid by very minute froth-bubbles. Its ſmooth ſurface poſſeſſed a great ſplendour, and was marked with diſperſed brown-red ſpots, reſembling agates.

No. 111. ZEOLITE, volcanic red; from the *ſame place.*

a) CH. Cr. Like No. 110. *a*)

b) CL. Cr. Like No. 110. *b*); only ſomewhat more turbid.

No. 112. CIRCON (Jargon); from *Ceylon.*

a) CH. Cr. No change, excepting that its colour turned white-grey, and its ſurface became a little more turbid.—Alſo no L. of W.

b) CL. Cr. Likewiſe unaltered. The greeniſh colour had almoſt diſappeared, and in its ſtead ſucceeded a reddiſh, bluiſh, and in part perfectly white one. Several pieces emitted a whitiſh luſtre.—No loſs of weight.

Concerning the utility which theſe experiments on fuſion may afford in various reſpects, I ſhall make only one or two remarks.

On reviewing the diviſion of ſtones and earths into *fuſible* and *infuſible*, which has been hitherto adopted, we obſerve that ſeveral of them are claſſed among the firſt; which, however, are not fuſible of their own accord, but acquire that property only by the co-operation of extraneous cauſes. Thus, if we obſerve the *Strontienite* (No. 91), the *Compound-ſpar* (No. 16), *Sidero-calcite* (No. 20), *Marble*, (No. 56), and in general all the ſpecies of calcareous earth, to vitrify in the melting-veſſels, it is owing to the *argillaceous earth* of the clay-crucible, which by its contact effects the fuſion of thoſe ſtony matters, which, when alone, are infuſible.

With reſpect to many other ſubſtances, the cauſe of their vitrification is their ferruginous contents; for *oxyd of iron* likewiſe promotes the fuſion of many compoſitions, otherwiſe not vitrifiable. This vitrification, therefore, cannot take place in *charcoal-crucibles*; becauſe in theſe, the calx of iron loſes its vitreſcent property, by being reduced to reguline iron, and hence is rendered incapable of continuing in chemical ſolution or combination with unmetallic-earths. It then ſeparates from them by a kind of eliquation.

An inſtance of this is afforded by the *Baſalt*, (No. 6—10), uſually repreſented as a body, which very eaſily melts into a black glaſs. But this fuſibility of baſalt obtains only when its ferruginous part finds no opportunity to be reduced and to ſeparate: for after this is withdrawn, the remaining portion of baſalt is no longer vitrifiable. It now appears, if examined by a lens, as a body almoſt wholly corroded; and it is not converted into a ſcoria, unleſs after continued expoſure to the moſt violent fire.

It is worth remarking, that, in the charcoal-crucible, not only is the iron of ſuch foſſils, as contain it in a very ſlight quantity, as *Pumice-ſtone* (No. 15), *Boracite* (No. 19), *Mica* (No. 38), completely reduced; but alſo, that even ſome ſpecies of ſtones, which in no manner undergo real fuſion, nay, which hardly ſeem to become ſofter, as the *Ligniform Aſbeſtus* (No. 11), *Chryſolite* (No. 25), *Brown-red Semi-opal* (No. 65), *Praſe* (No. 72), and *Serpentine* (No. 80), do nevertheleſs depoſite, as it were by exſudation, moſt part of their iron.

The proportion of the ferruginous contents thus diſcovered, may ſerve at the ſame time to determine in dubious caſes the claſſification in the mineralogical ſyſtem. That is to ſay, it may aſſiſt to decide, whether a foſſil, whoſe proportion of metallic parts is as yet unknown, ſhould obtain a place in the claſs of earths and ſtones; or, whether it ought to be ranged in the genus of iron-ores.—Such is the caſe with *Umber*. Of one hundred parts of umber from *Cyprus* (No. 102), there remained 67; and the iron, reduced from this reſiduum, amounted to 37; but the vitreous ſcoria, only to 30.—Of one hundred parts of *umber* from *Cologne*, there likewiſe remained 67, of which 35 were iron, and 33 were ſcoria. This mineral, therefore, as much deſerves a place under the genus of iron-ores, as ſeveral other iron-ores, leſs rich in ferruginous contents. It may be conſidered, either as a particular ſpecies of the brown iron-ſtone; or as a variety of brown iron-ochre.

Beſides, the trials made with fire may be of ſome utility with regard to thoſe foſſils, concerning which the opinions of the learned are yet divided, with regard to the means employed by nature for their formation. I even think, that in this branch of *geological* reſearches, the experiments made by *means of fire*, are rather more deciſive than the analyſis in the *moiſt-way*. Although it is quite contrary to my intention to enter into this diſpute, yet I think myſelf obliged to ſtate my own private opinion reſpecting this ſubject, independent of the authority of others; which is, that I cannot rank among the products of fire, either the genuine *baſalt*, or its kindred *wacke*, or the *porphyric-ſlate*. In this perſuaſion I am confirmed by perſonal inſpection of baſaltic diſtricts, eſpecially of the *Bohemian middle mountains*; as well as by the habitudes of the above minerals in fire. No. 6—10; 105; 70.

On the contrary, as to what relates to the generation of the *Obſidian* (No. 58, 60), *Pumice-ſtone* (No. 15), and pretended *Volcanic Zeolite* (No. 111, which laſt is reckoned by ſome among the *Pitch-ſtones*), &c, I willingly renounce my own opinion; adding only, that, on conſidering the arguments for and againſt their volcanic origin, the circumſtance of the obſidian and pumice-ſtone giving in fire exactly the ſame products, ſhould not be diſregarded; and alſo, that both theſe foſſils, not only accompany each other at *Lipari*, but likewiſe frequently occur actually blended.

As the chemical analyſis in the humid way is embarraſſed with many difficulties, that check the progreſs of our knowledge of the conſtituent parts of foſſils; the ſpeedier examination, by means of fire, of a foſſil, not yet analyſed, may ſerve as a previous hint for aſſigning to it its proper place in the ſyſtematical arrangement. It may alſo tend to correct the claſſification of ſeveral minerals whoſe characters are not ſufficiently diſtinct, or perhaps have led to error. So, for inſtance, the above reſults plainly ſhew, that the *Cats-eye* is not a fel-ſpar (No. 48, 49); that the *Leucite* does not belong to the garnets, and as little to the fel-ſpar (No. 55); that the *Telkebanya-ſtone*, or *brown-red Semi-opal*, is not allied to the vitrifiable pitch-ſtones, among which it has been ranged on account of its perfect opacity (No. 65); and that the *Granatite* cannot be claſſed under the garnets (No. 41); nor the *Cyanite* under the ſtriated ſhörls (No. 28); nor the *Chlorite*, under the varieties of mica (No. 23.)

However, the inferences drawn from theſe experiments, ſhould not be carried too far; nor ſhould a deciſive concluſion be made on the conſtituent parts of a foſſil, merely from its changes in the fire. For, in this reſpect, the *analyſis in the humid way* is abſolutely the only ſafe guide.

II.

ANALYSIS

OF THE

BLACK-GREY FLINT.

(Common Flint; *Feuerſtein* of the Germans.)

In order to reduce to the requiſite moſt ſubtle pulverulent ſtate the harder kinds of ſtones, which are to be ſubjected to a chemical analyſis, I make uſe of a grinding concave ſhallow veſſel or bowl, wrought, as well as its appropriated mullar, of black-grey flint. The body, which is to to be finely ground in it, being previouſly pulverized in a poliſhed ſteel-mortar, gently ignited and accurately weighed, I moiſten with water, and continue the trituration, until the ſtone is reduced to an impalpable powder. A ſhorter or longer time is neceſſary for this operation, according to the degree of hardneſs; ſo that 100 grains of the more indurated ſpecies of gems often require triturating for three or four hours. After the finely powdered maſs is again deſiccated in the air, or in a gentle warmth, I ignite the powder, carefully collected from the triturating-diſh, in a ſilver or porcelain-crucible, with a low heat, and weigh it once more.

Stones, the hardneſs of which does not ſurpaſs that of flint, weigh then no more than at firſt. But ſuch as are harder than flint, acquire an increaſe of weight; which in ſome gems, as the ſapphire, adamantine-ſpar, and chryſo-beryl, often amounts to from 10 to 13 *per cent.*

Therefore, as this addition of weight muſt, of courſe, be again ſubtracted from the ſum of the conſtituent parts of the decompoſed body, an exact chemical knowledge of the ſubſtance, of which the grinding veſſel conſiſts, is indiſpenſable. And, no doubt, common flint would be little eligible for the grinding of hard ſtones, if, beſides the ſilex, its chief ingredient, it contained other earths in that quantity, which is ſtated by mineralogiſts; and of which aluminous earth is ſaid to make up from 18 to 20 parts in the hundred.

But from an exact and repeated analyſis of this flint, I am convinced that the quantity of foreign earths, which are here combined with the ſilex, is far leſs conſiderable, and that in general the ſum of them only amounts to *one grain.* On this account, and conſidering the ſmall number of grains abraded from the flint mortar, it would appear a ſuperfluous nicety, to bring into calculation the ſmall fractional parts of the other earths, beſides the ſiliceous.

a) *Five hundred* grains of common flint, coarſely bruiſed, were ignited for half an hour in a covered crucible. They loſt, by this, five grains of weight, and turned greyiſh-white.

b) *A Hundred* grains of flint, reduced to the fineſt powder, were mingled with three times their weight of cauſtic pot-aſh, and expoſed to a red-heat in a ſilver-crucible for half an hour; by which management, however, the mixture did not fuſe, but continued a looſe, friable maſs. When covered with water, it was all diſſolved, without any reſidue, and afforded a ſomewhat turbid liquor.

c) By over-ſaturating this ſolution with muriatic acid, the *ſiliceous earth* was precipitated; which, after a due digeſtion, was ſeparated, waſhed, and ignited.—It weighed 97 grains.

d) The acid fluid, thus ſeparated, when ſaturated with carbonat of ſoda, let fall a browniſh earth; which re-diſſolved in muriatic acid, and left ſiliceous earth, weighing one grain after ignition.

e) The remaining muriatic ſolution afforded, with cauſtic ammoniac, a brown, mucilaginous precipitate; which, when added, while yet moiſt, to cauſtic lye, depoſited *oxyd of iron*, weighing after ignition one quarter of a grain.

f) When this portion of iron had been ſeparated, I mixed the cauſtic lye with muriatic acid to exceſs. Being then ſaturated with mild ſalt of tartar, it was put in a warm place. A ſmall portion of earth fell down; which, after gently drying, weighed one half grain, and its ſolution in ſulphuric acid afforded aluminous cryſtals. This aluminous earth would have weighed one quarter of a grain in its dry ſtate.

g) The edulcorating waters, after being collected, evaporated to dryneſs, and the reſidual ſaline maſs, again diſſolved in freſh water, depoſited three quarters of a grain more of an earth, which diſſolved in muriatic acid, with effervеſcence, and yielded ſelenite or gypſum, on dropping ſulphuric acid into it. It was conſequently *calcareous earth*, which, if free from carbonic acid, would have amounted to half of a grain.

Hence the conſtituent parts of common flint amount in *one hundred* to

Ignited *ſilex*	c)	97	98,
	d)	1	
— — — *Lime*	g)		0,50
— — — *Alumine*	f)		0,25
Ignited *oxyd of iron*	e)		0,25
Parts volatile in fire	a)		1,
			100

III. CHEMICAL

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III.

CHEMICAL EXPERIMENTS

ON THE

ADAMANTINE SPAR.

FIRST SECTION[*].

NATURE, inexhauſtible in its riches, has intended, as it were, to keep in activity the ardour of Naturaliſts, in the diſcovery, examination, and arrangement of the foſſil products, by preſenting new ſpecies that have remained hitherto unknown, and whoſe proper place has been too frequently miſtaken in artificial claſſifications. This truth has been confirmed, in an eminent degree, by the *adamantine ſpar.*

The native places of this ſtone are *China* and *Bengal*; and from each of theſe countries it was firſt brought to Europe, for the celebrated cabinet of *Charles Francis Greville*, Eſq. in London. The denomination of *adamantine ſpar*, given to it by Engliſh Naturaliſts, is grounded not only on its uncommon hardneſs, ſimilar to that of diamond;

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[*] Read in the Royal Acad. of Sciences at Berlin. See *Recherches chymiques ſur le Spath adamantin*; in the *Memoires de l'Acad. royale ete, Août* 1786, *juſqu' à la fin de* 1787. Berlin 1792.

but alſo on its application; for the Chineſe and Indian lapidaries make uſe of the powder of this ſtone inſtead of the real diamond-powder for grinding.

The firſt public notice taken of the adamantine ſpar which I know of, is contained in the ſecond Volume of *Sage's Analyſe chymique et concordance des trois regnes*; where this writer ſtates the above foſſil to be a granite, compoſed of fel-ſpar, black-ſhörl, and quarz. A more accurate account of it, together with a deſcription of its external appearance, was afterwards given by *de la Metherie* and *Abbé Hauy* in *Rozier's Journal de Phyſique*, for January and March 1787.

But as no Chemiſt has ventured to undertake its chemical analyſis, *Mr. Greville* was ſo obliging as to ſacrifice a quantity of this ſubſtance, in his poſſeſſion, ſufficient for its examination, and to ſend it me for that purpoſe.

The adamantine ſpar preſents two diſtinct varieties, according to the two different countries which give it birth. The firſt, which is found in China, when regular, aſſumes a columnar form of ſix ſides, without terminating points. The ſize of the ſpecimens which I have ſeen, was from an half to a full inch in height, and three quarters of an inch in thickneſs.

The colour of this ſtone is grey, of various ſhades, partly verging to the brown of hair. The entire pieces are opake; but in thin lamellas, and on the edges tranſparent. Its fracture is gloſſy, and exhibits a fine ſpatoſe or foliated texture; on account of which, even its outer ſurface appears finely ſtriated. Its lateral facets are moſtly coated with a delicate, firmly adhering cruſt of micaceous ſcales of a ſilvery luſtre, and in ſome places intermingled with particles of red fel-ſpar.—One ſpecimen was alſo covered with a delicate yellow *ſulphur pyrites.*

This ſtone is exceedingly hard. For this reaſon, it not only cuts glaſs with as great facility as diamond, but it alſo ſcratches rock-cryſtal and other hard ſtones, and is employed, as already mentioned, for cutting and poliſhing even gems.

Its ſpecific gravity I found to be 3,710.

An accidental characteriſtic mark of this Chineſe adamantine ſpar is, that it contains magnetic iron, diſſeminated in ſmall cryſtalline grains, which are eaſily ſeparable by means of the load-ſtone, if the ſtone has previouſly been bruiſed to a moderately fine powder.

The ſecond variety, or Indian adamantine-ſpar, from Bengal, called by the natives *Corundum*, is diſtinguiſhed from the Chineſe by a whiter colour, by a more decidedly ſparry texture; and by the magnetic iron, which it likewiſe contains, conſiſting of ſtill ſmaller grains, but not interſperſed within its ſubſtance, but merely adhering to its ſurface.

With the *Chineſe Adamantine Spar* I made the following Chemical Experiments.

By ſtrong ignition for an hour it loſt 1⅞ *per cent.* of weight; but ſuffered no alteration, except having become a little whiter. Before the blow-pipe upon charcoal, it was not in the leaſt attacked, either by ſoda, or by borat of ſoda; or by the compound of phoſphat of ſoda and ammoniac (*phoſphoric ſalt of urine.*)

In order to guard againſt accidental impurities, I bruiſed the ſtone on the anvil, between many ſheets of ſtrong paper. I then picked out the pureſt pieces; heated them to redneſs, and quenched them in water. However, this operation being ſeveral times repeated, was found uſeleſs; and the hardneſs of the ſtone was not at all thereby diminiſhed. It was next triturated in an agate mortar to the fineſt powder; and upon 300 grains, or five drachms of this powder, introduced into a retort, twice its weight of aqua regia was poured. By ſtrong digeſtion, I obtained from it a golden-yellow tincture of iron. This digeſtion was once more repeated with a freſh quantity of the ſame acid. I then precipitated the diſſolved iron by cauſtic ammoniac; which precipitate, after edulcoration and ignition, was all attracted by the load-ſtone.

My next ſtep was to examine whether the decanted fluid contained calcareous earth.—For this purpoſe I combined it with mild ammoniac; but no trace of this earth appeared. Therefore the acid had only extracted that portion of iron, which is ſimply diſſeminated in the adamantine ſpar; but does not belong to its compoſition.

The powder remaining after the extraction of the iron was of a bright aſh-grey. This I mixed with double its weight of ſalt of tartar*, and ignited it in a ſilver-crucible, during two hours in a briſk fire. But on ſoftening again this maſs by diſtilled water, I ſoon perceived, that no *reſolution*, or ſeparation of parts, had taken place in the intrinſic mixture, or compoſition of the ſtone: nor did the alkaline ſolution let fall any precipitate, when ſaturated with acids.

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* Pot-aſh, or vegetable alkali, prepared from tartar.

Convinced by other experiments, that the cauſtic fixed alkalis have a ſtronger *reſolvent* power, than the mild over ſtones of a firmer texture, I reſolved to repeat the operation with the cauſtic alkali. With this view I prepared cauſtic ſoda, with all the precaution neceſſary for obtaining it in a perfectly pure ſtate.

Equal parts of this cauſtic ſalt, and of the powder of adamantine ſpar, were ſubjected to ignition in a ſilver-crucible for the ſpace of two hours. After this, the calcined maſs, which had become very compact and hard, was triturated with diſtilled water; ſuper-ſaturated with muriatic acid, and digeſted. The acid extracted merely a pale yellow tincture, which ſtill contained a ſlight ferruginous impregnation; but nothing of an earthy nature. When the reſidual powder was again waſhed, and ignited, it was of a light grey-white colour, and weighed 240 grains. So that 60 grains, making the fifth part of the firſt weight of the crude ſtone, muſt be taken for the iron diſſeminated in, and now ſeparated from it by acids.

Theſe 240 grains I mixed with four times their weight of cauſtic mineral alkali; and ignited them in a crucible made of ſilver, as long as the veſſel would bear it, without itſelf fuſing. After refrigeration, the maſs was ſo firm and ſo hard, that in order to bring it on the filter, I was under the neceſſity of ſoftening it by long tedious boiling in diſtilled water. The alkaline ſolution, ſaturated with muriatic acid, now dropped a white, very looſe earth; which, from previous conjecture, I then imagined to be ſiliceous. But this was not the caſe, for it was rapidly and clearly re-diſſolved by a ſlight exceſs of acid, and proved to be rather aluminous on farther trial. And by accurately ſaturating the ſolution with ſalt of tartar, I reproduced it again in the form of a precipitate, and collected it.

The powder, left on the filtering-paper, had an iſabella-yellow colour, and had become looſer. I poured upon it four parts of aqua regia; but it ſoon formed with it a thick gelatinous coagulum. Having added four parts more, I digeſted the mixture in a boiling heat. Which being done, it was diluted with hot water, and, after filtration, ſaturated with ſalt of tartar. By this management a white looſe earth precipitated, and was aluminous, like the preceding.

I next repeated the ſame operation with the 140 grains of the powder of this ſtone that remained in the laſt-mentioned proceſs: that is to ſay, I added four parts of cauſtic ſoda, and heated it to redneſs for five hours in a ſilver-crucible. As in the preceding experiment, ſo in this, the maſs became exceedingly hardened, and of difficult ſolution, even in boiling water. Its filtered lye likewiſe depoſited, on the addition of muriatic acid, a white looſe earth; which, in the ſame manner, entirely diſſolved without any turbidneſs, by an exceſs of the acid. Having been again precipitated by mild alkali, I collected and added it to that which was obtained in the laſt proceſs.

In the ſame manner, as mentioned above, I treated the reſidue that remained behind on the filter after the ſeparation of the alkaline lixivium, by digeſting it in aqua regia; and the ſmall portion of earth, extracted from it, was likewiſe precipitated by ſalt of tartar.

The undecompoſed part of the powder, which at this period weighed 103 grains, I ſubjected a ſecond time to calcination,

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hation, during five hours, being previouſly mixed with a quadruple proportion of cauſtic alkali. The reſult agreed with that of the foregoing proceſs. From the filtered alkaline ſolution of the maſs, ſoftened with difficulty, acids threw down a ſlight quantity of looſe earth; which was re-diſſolved when the acid was added to exceſs. Having been again precipitated by the addition of alkali, it was then collected.

I next put the edulcorated reſidue, weighing now but 92 grains, in digeſtion with ſix parts of nitric acid. The powder of the undecompoſed adamantine ſpar continued, as before, lying at the bottom, like an heavy fine ſand. But when the mixture had begun to boil, I perceived an unexpected alteration. The powder ſwelled; roſe from the bottom of the matraſs towards the ſurface of the liquid, and changed its ſandy appearance to that of a flocculent precipitate, nearly of the ſame form, with recently precipitated muriat of ſilver; but, on continuing the digeſtion, it again fell down in the form of an incoherent powder. This laſt acid likewiſe extracted a ſmall portion of alumine; which I collected, after precipitating it by pot-aſh.

The remaining powder of the adamantine ſpar, whoſe weight after ignition amounted to 74 grains, was treated in preciſely the ſame manner as before, only with this difference, that I increaſed the proportion of cauſtic alkali, of which I now took a ſextuple weight. After the maſs had been ignited for five hours, and refrigerated, it was found, as in every previous operation, to be very difficulty ſoluble in boiling water. At this time, by the addition of an acid to the filtered ſolution, a leſs quantity of looſe earth, than before, was precipitated; but which even now was not ſiliceous earth. Boiling nitric acid likewiſe extracted from the reſidual powder a little aluminous earth.

When

When the adamantine powder, remaining after theſe repeated ſtrong calcinations with alkali, was put on the balance, its weight was found to be 60 grains. It appeared now in the form of a fine, ſiliceous earth; and in order to examine it as ſuch, I mingled it with one ounce of mild ſoda; upon which it was ſtrongly calcined in a ſmall ſilver-crucible, and at length urged to fuſion. The crucible was left uncovered; becauſe I intended to watch attentively, whether the blended maſs would efferveſce, during the action of the carbonated alkali, and thus betray a ſiliceous nature. The fuſion, however, went on without the leaſt frothing; and by this I was ſufficiently convinced, that the earth under trial was not yet purely ſiliceous.

The melted maſs proved, after refrigeration, to be as difficult of ſolution in water, as before. This alkaline lye, paſſed through the filter, ſhewed no appearance of having taken up any foreign ſubſtance. It remained perfectly clear and limpid, when ſaturated with acids; ſome few, hardly perceptible flocks, excepted.

I now endeavoured to ſeparate ſomething from the reſidue, again edulcorated, by means of ſtrong ſulphuric acid. Eight times its weight of this acid was accordingly poured upon it, and again with proper precaution diſtilled off from it to dryneſs. The reſidue, ſoftened by hot water, was put on the filter, and the acid liquor, which paſſed through the paper, was ſaturated with pure vegetable alkali. Yet, even with this treatment, I only obtained a very ſlight indication of alumine.

On conſidering this great obſtinacy of the remainder left from the adamantine ſpar, which by the laſt operation hardly loſt one grain of weight, I again recurred to the cauſtic mineral alkali. The powder, mixed with a tenfold quantity of ſoda, was firſt ignited for four hours; increaſing afterwards the intenſity of heat, until the maſs entered into a thin fuſion, in which ſtate it was kept two hours. The ſilver-crucible would not longer reſiſt the action of the fire; it was injured, though without detriment or loſs of the maſs, which was again with difficulty liquified in water, and then filtered.

The alkaline lixivium, thus obtained, depoſited a tender earth, upon ſaturation with acids. But even this earth was not yet ſiliceous. It diſappeared by a ſlight exceſs of the acid; and ſeparated again, as ſoon as the point of ſaturation was reſtored, by the addition of alkali. When thus recovered, it was freed from adhering ſaline particles by waſhing, and added to the precipitates, obtained in the preceding operations.

Upon the remaining portion of adamantine ſpar in a pulverulent ſtate, which in this proceſs again had aſſumed an iſabella-colour, I then affuſed four parts of nitric acid. The mixture thickened to a jelly; on which account I added four parts more of nitric acid, and digeſted it in a boiling heat. The ſolution being diluted with water, and filtered, was ſaturated with ſalt of tartar; and the precipitate which it afforded, added to the preceding ones.

At this period, the quantity of adamantine ſpar, which had hitherto reſiſted decompoſition, weighed 34 grains; which were mixed with 15 times their weight of cauſtic ſoda, and ignited in a briſk fire, during five hours. Yet, notwithſtanding this, the alkaline lye, procured from the re-diſſolved maſs, and ſaturated, depoſited only a trifling quantity of a flocculent earth; and for this reaſon no diminution of weight was obſervable in the reſidue.

Digeſted

Digeſted with eight parts of nitric acid, the mixture again acquired a gelatinous conſiſtence: and the acid, ſeparated by filtering, likewiſe afforded only a ſcanty precipitate, on being ſaturated with alkali.

The powder, ſtill undecompoſed, weighed now 27 grains; which I blended again with 15 parts of cauſtic ſoda, and treated in the manner oftentimes ſtated. But I obſerved that the alkali, as well as the ſubſequent digeſtion in acids, extracted from it ſtill leſs than before; ſince the remaining undecompoſed part amounted yet to 24 grains.

I then reſolved to try, whether perhaps a ſtronger degree of heat, than the ſilver-veſſel was capable of bearing, might not give additional force to the action of the alkaline ſalt, and thus effect the farther decompoſition of this ſtubborn reſidue. I therefore ſubſtituted an iron-crucible to that of ſilver. This reſidue, being mixed with four parts of mild pot-aſh, and introduced into the iron-crucible, was expoſed to a heat ſufficiently intenſe to cauſe it to melt, and it was then kept for two hours in red fuſion. This obſtinate body, however, could not be maſtered. The liquor, ſeparated from the diſſolved maſs, held no atom of earth in ſolution; but remained clear, when ſaturated with acids.

After the reſidue, left on the filtering paper, had been freed by means of the muriatic acid from the particles of iron which it had acquired from the melting-veſſel, and after it had been edulcorated and dried, I found it poſſeſſed of the ſame nature as before; and only one grain of its weight was wanting, which I ſuppoſe was not diſſolved, but loſt.

Having thus *eleven times* calcined and fuſed this ſtone, with alkali in various proportions, I at laſt gave up all hopes of conquering this reſidue, which at each operation proved more and more refractory. And not expecting ſucceſs, even from repeating theſe tedious proceſſes, that exhauſted all patience, I turned my attention to the examination of the ſeveral precipitates that had been collected.—But I found that thoſe which were obtained, by means of acids, from the ſolutions of the maſſes calcined with alkali, were of nearly the ſame nature as the precipitates, thrown down by alkalis from the acids, in which the adamantine ſpar was digeſted or extracted after every calcination. For this reaſon I mixed them all together, and choſe the ſulphuric acid, as the proper teſt for their examination. This menſtruum, conſiſting of one part of the concentrated acid, diluted with four parts of water, immediately diſſolved a conſiderable part of the earthy precipitate; but another portion remained undiſſolved, though the acid had been added to exceſs, and was aſſiſted by a boiling heat. Upon this undiſſolved earth, when ſeparated by filtration, edulcorated, dried, and introduced into a retort, I poured four times its weight of concentrated ſulphuric acid; and having again abſtracted this laſt, by diſtillation, to dryneſs, in a ſand-bath, I ſoftened the reſiduum with boiling water, placed it on the filter, and edulcorated the earth remaining on the paper. I found, however, that by this treatment, nothing of importance could be extracted from this earth; for the ſolution, ſaturated with alkali, yielded only one half grain of precipitated aluminous earth, which I re-diſſolved in ſome drops of ſulphuric acid, and added to the preceding ſolution

A ſmall proportionate quantity of pure vegetable alkali being added to this ſolution, it was made to cryſtallize by repeated gentle evaporations; after which it ſhot into regular cryſtals of alum, which were collected.

I obſerved, however, that on every cryſtallization of this ſolution of alum, a white ſlimy earth was ſeparated.

I therefore

I therefore collected it carefully, and treated it in the ſame manner as the earth mentioned before: that is—I diſtilled from it four times its weight of ſtrong ſulphuric acid; ſoftened the reſiduum in the retort with water; filtered the liquid which had diſtilled over, and ſaturated it with alkali. But hardly one half grain of earth fell down, and this was ſtill aluminous. The earth which remained undiſſolved, exactly reſembled that which has been mentioned before, and was accordingly added to it.

Thus I at length ſo far ſucceeded, as to decompoſe the adamantine ſpar into two different ſpecies of earth. But though the firſt evidently ſhewed itſelf to be aluminous, the nature of the ſecond was doubtful. On ſuperficial conſideration, this laſt might well be taken for ſiliceous earth; but its habitudes contradicted this ſuppoſition.

Encouraged by the hope of coming nearer to the diſcovery of its true nature, I repeated the operation ſo frequently noticed, of heating it to intenſe redneſs for ſome time, with ſix parts of cauſtic ſoda in the ſilver-crucible, and increaſing at laſt the ſtrength of the fire ſo as to affect its thorough fuſion. The melted maſs had then acquired a ſtriated cryſtallic texture. Yet the alkali took up but a ſmall portion of it, as I found by the weight of the undiſſolved earth, recovered from the calcined maſs, after liquefying it by water. The reſidue, waſhed and dried afreſh, was boiled for an hour with ten times its weight of ſtrong nitric acid; from which, when ſeparated again, and ſaturated with alkali, only an inconſiderable trace of alumine fell down.

I then ſaturated with nitric acid the alkaline ſolution obtained from the melted maſs. It let fall a ſlight quantity of fine a fine earth; not a particle of which was diſſolved by nitric acid boiled upon it for ſome time.

This portion of earth, which was precipitated, and recovered by filtration, ought at laſt, agreeably to theory, to have aſſumed the character of pure ſiliceous earth. To make trial of it, I expoſed it with ſoda to the action of the blow-pipe, in a quantity not exceeding three grains. But it did not prove to be ſiliceous; on the contrary, I found it to be of the ſame nature with the whole of the remaining earth, from which it was ſeparated by the mineral alkali during the fuſion.

However, in order to make a comparative experiment with real ſiliceous earth, I mingled a drachm of this laſt, precipitated from liquor of flints, with four drachms of cauſtic ſoda, and expoſed them together, in a ſilver-crucible, to only a moderate ignition. Although this maſs was hardly agglutinated by the operation; yet it eaſily afforded a clear ſolution in diſtilled water. And when this was ſaturated with an acid, the ſiliceous earth fell down, in its uſual manner, in the form of a jelly-like ſubſtance, highly intumeſced.

From all theſe proceſſes it is ſufficiently obvious, that the adamantine earth in no manner acts like the ſiliceous. If it were ſo, it ſhould diſſolve in fixed alkalis, by means of a red heat; more eſpecially when cauſtic alkalis are employed, as was here the caſe: and it likewiſe ſhould be recoverable from them by affuſion of acids. But the earth, which after the firſt fuſions, was thrown down by acids from the alkaline ſolutions, was not ſiliceous, but aluminous, which was immediately and entirely re-diſſolved by adding more of acid. And in proportion as the alumine was ſeparated from the mixture of the adamantine ſpar, by alkalis as well as by acids, the unknown earth in queſtion more and more reſiſted each ſolvent medium.

If ſiliceous earth, blended with equal parts, or with only one half of its weight of fixed alkali, be expoſed to a melting heat, it unites with ſtrong effervescence to the alkali, and affords a clear glaſs. And this reſult enſues both in the crucible, and before the blow-pipe, in ſmall experiments. But this is not the caſe with the other earth. When brought before the blow-pipe in a ſmall ſilver ſpoon, a little effervescence ſeems indeed to take place at the beginning of the fuſion; but neither is the effervescence ſo ſtrong, nor is there a clear vitreous globule formed, as in the firſt inſtance. Only a ſcorious maſs, of difficult fuſion, remains.

A frit, compoſed of twenty grains of this earth, with as much carbonated ſoda, was expoſed in a luted clay-crucible, to the ſtrongeſt heat of the porcelain-furnace, which is ſo intenſe, that carrara-marble, or any other calcareous earth, if incloſed in a clay-crucible, melts without any addition, into a very hard, clear, and green glaſs. The reſult of this experiment was, an opaleſcent, very hard, greeniſh-white glaſs; the fracture of which, however, exhibited ſigns of a texture, in divergent lines, radiated from a common centre at the bottom of the melted maſs. Whereas ſiliceous earth, precipitated from the liquor of flints, when mingled with equal parts of ſoda, as was to be expected, yielded a clear glaſs in the ſame degree of heat.

What am I then to think of this earth? Shall I, perhaps, take it for a mixture as yet not totally decompoſed, of two or more ſimple earths, perhaps the aluminous and ſiliceous?—This opinion is *not without probable ground.* The extreme obſtinacy with which the adamantine-ſpar reſiſts all attempts to decompoſe it, ſhews us the high degree of attractive power, by which nature has moſt intimately mixed and united the conſtituent parts of this ſtone. Hence, in proportion as the aluminous earth was forced out and ſeparated from the mixture of this ſtone, ſeemed the laſt reſidue, which, for a moment, I will ſuppoſe to be ſiliceous, to be more ſtrongly attracted, and ſecured againſt farther ſolution, by its other remaining conſtituent parts, in the ſame manner, perhaps, as ſilver is defended by gold from the attack of nitric acid, when the firſt is united with the latter by fuſion, in a proportion ſmaller than two to one.

But this *analogy* ſubſiſts only in appearance, and it might be applied only in the decompoſition of the adamantine ſpar, by means of acids. For, in that caſe, the ſiliceous earth, becauſe itſelf inſoluble in acids, might protect the alumine which is moſt intimately combined with it; in the ſame way as gold, by its inſolubility in nitric acid, preſerves the ſilver againſt the action of the ſame acid, which in general ſo readily diſſolves it. On the contrary, this example does not ſeem very applicable to the decompoſition of this ſtone, in the dry way, by means of alkali; ſince, in this caſe, both earths, the alumine as well as the ſilex, are ſoluble in fixed alkalis.

Beſides, the above conjecture is oppoſed by another circumſtance. We are taught, by experience, that mixed bodies, whoſe conſtitutent parts are ſtrongly attracted by each other, may certainly, for a long time, reſiſt the force of ſolvents; but we alſo know, by experience, that, whenever the ſolution has actually taken place, eſpecially when in the humid way, the reciprocal attractive power of the conſtituent parts is then either totally deſtroyed, or, at leaſt, ſo far diminiſhed, that nothing impedes their ſeparation.

This is the caſe with the earth of the adamantine ſpar: for it has actually been diſſolved, conjunctively with the aluminous earth, partly in acids, partly in the alkaline lyes. And it has alſo been recovered, in the form of a precipitate, from both kinds of ſolvents.

What inference, therefore, remains?—This earthy ſubſtance would not give any further indications of a mixture; and yet it preſented none of the ſpecific characteriſtic marks by which the other ſimple earths, at preſent known, are diſtinguiſhed. Are we not, then, authorized to regard this body as a *new*, *diſtinct*, *ſimple* earth?—However, I do *not* venture, at this time, poſitively to decide on this point. Before this can be done, *repeated experiments muſt throw more light on the nature of this earth.* Yet, conſidering the ſcarcity of adamantine ſpar, and its diſcouraging reſiſtence to chemical analyſis, there is little hope for a ſpeedy ſucceſs.

It now remains, to ſtate the *proportion* of the parts found in the adamantine ſpar.—The grains of *magnetic iron* diſſeminated through it, conſtituted the fifth part of its whole weight; for when they had been ſeparated, there remained 240 grains of the 300 employed. But this iron cannot be brought into the computation as a conſtituent part of the ſtone.—Its proper conſtituent parts are, *aluminous earth*, and the above *yet undetermined earth*. After all the aluminous earth, collected in this analyſis, had been diſſolved in ſulphuric acid, and properly cryſtallized, I obtained from it 2 ounces 6 drachms of alum, in regular cryſtals. As, therefore, the alumine contained in one ounce of this neutral ſalt, amounts, when ignited, to 56 grains, it is manifeſt, that thoſe 2 ounces 6 drachms of cryſtallized alum contain 154 grains of aluminous earth, free from water.

The other yet undetermined earth weighed, after ignition, 53 grains. To theſe muſt be added the reſidue of 24 grains, which remained at laſt, on the decompoſition of the ſtone, and was inſoluble, and perfectly like the other portion. Hence this earth amounts, in the whole, to 77 grains; which, with the 154 grains of aluminous earth, give the ſum of 231 grains.

SECOND SECTION.

THE circumſtantial deſcription of my firſt analytical attempt reſpecting the adamantine ſpar (communicated in the foregoing ſection), may ſerve as an example to ſhew the difficulties chemiſts have but too often to contend with, when examining unknown natural bodies. If the method of decompoſing hard ſtones, purſued in my former enquiry, be compared with the proceſs which will be explained in the preſent ſection, it will alſo appear from thence, how ſeemingly unimportant the cauſes often are which at one time enſure ſucceſs to the undertaking, at another time render it difficult.

By the reſults of the above experiments, I was induced to enquire, whether that earthy body, which was obtained beſides the aluminous earth, did not deſerve to be conſidered as a new, peculiar earth. However, I accompanied this conjecture with the expreſs declaration, that I did not then mean to aſſert any thing certain; but, on the contrary, that farther experiments could alone decide that queſtion. Nevertheleſs, I find this ſubſtance mentioned by ſeveral authors as an earth, the exiſtence of which has been already proved, and named by them *Earth of Adamantine Spar*, *Corundum-earth*, *&c.*

On this account, I thought myſelf the more bound to make new reſearches on the adamantine ſpar, and to give, if poſſible, a *complete decompoſition* of it, inſtead of the former preliminary and unfiniſhed examination. Two reaſons impoſe upon me this taſk; either to throw full light upon its nature if it ſhould, on farther examination, prove to be really a diſtinct and new earth; or, if the contrary be the caſe, to prevent in time the ſpread of an error, occaſioned againſt my intention.

The want of a ſufficient additional quantity of this foſſil, which ſtill continues to be ſcarce in Europe, has, however, retarded the execution of this purpoſe for a conſiderable time; but other experiments, conducted during that period, have made me acquainted with a ſhorter and more certain method of analyſing gems, and other ſimilar foſſil bodies, of difficult decompoſition.

A.

Decompoſition of the Chineſe Adamantine Spar.

a) *Hundred and fifty* grains of hair-brown adamantine *ſpar*, from *China*, containing interſperſed particles of magnetic iron, were powdered by gentle blows in a mortar of poliſhed ſteel, and the grains of iron extracted with the load-ſtone. The ſeparated iron weighed 18 grains.

b) *Hundred* grains of the powder from this ſtone were then weighed, and moſt finely levigated, moiſtening them with water, in a triturating-diſh, made of flint. After deſiccation the powder appeared of a grey colour, reſembling that of wood-aſhes, which paſſed into a brown-red, after gentle ignition. It now weighed 110½ grains, and conſequently had received an increaſe of 10½ grains of ſiliceous earth from the grinding-veſſel.

c) After this it was mixed in the ſilver-crucible with 4 ounces of cauſtic lixivium, prepared from the pureſt vegetable alkali, the ſaline contents of which lye amounted to one half of its weight; and after this the fluid was again evaporated, till the maſs was dry. This done, the crucible was removed into the wind-furnace; applying at firſt a moderate heat, and increaſing it gradually, until the crucible was red-hot; in which ſtate it was kept for 3 hours.

d) Upon the refrigerated maſs, which had acquired a brown colour and conſiderable hardneſs, I repeatedly poured hot water, to ſoften it by degrees. The ſeveral waſhings being collected in one glaſs, there fell down a looſe earth of a deep ochre-yellow tinge, which, when ſeparated by filtration from the clear liquid, and dried in a gentle heat, weighed 58 grains.

e) Muriatic acid threw down from this alkaline ſolution a copious precipitate, which was again wholly diſſolved by a ſlight ſuper-ſaturation with the acid. When decompoſed by a boiling ſolution of carbonat of pot-aſh, it produced a white looſe earth, the quantity of which amounted, after gentle deſiccation, to 201 grains.

f) The above 58 grains of yellow earth (*d*) were covered with muriatic acid, and committed to digeſtion. It diſſolved in it to a yellow liquid, ſomewhat turbid, which ſoon after formed a gelatinous coagulum. After being diluted with more water, and digeſted, ſtirring it now and then, it depoſited *ſiliceous earth*, which, when ignited, gave 4½ grains in weight.

g) I then added mild vegetable alkali to the clear yellowiſh ſolution, ſeparated from the ſiliceous earth by filtering. The browniſh precipitate, which I thus obtained, was ſufficiently edulcorated, and, while yet moiſt, boiled with cauſtic lye. There remained a brown reſiduum, conſiſting of 15½ grains, after a gentle drying.

h) Theſe 15½ grains diſſolved in the cold, in the muriatic acid poured upon them, and afforded a ſaffron-yellow ſolution, but which ſpeedily congealed to a jelly. From this laſt, diluted in heat with water, there ſeparated *ſiliceous earth*, whoſe weight, after ignition, was 3 grains.

i) From the muriatic ſolution (*h*) I now precipitated, by cauſtic ammoniac, the iron which it contained. It fell down in brown-red flocks, and weighed 7½ grains, after being expoſed to a red-heat.

k) From the alkaline ſolution (*g*), ſaturated to exceſs with muriatic acid, the addition of mild vegetable alkali precipitated, in a boiling heat, a white looſe earth, which, being gently dried, weighed 29½ grains.

l) Upon theſe 29½ grains of earth (*k*), added to the above 201 (*e*), dilute ſulphuric acid was affuſed. When gently warmed, the earth was entirely diſſolved; but when the ſolution had been concentrated by evaporation, it coagulated into an uniform clear jelly. This was again copiouſly diluted with water, in a warm temperature, and with repeated ſtirring; upon which *ſiliceous earth* ſeparated, amounting, when dried and expoſed to a red-heat, to 9 grains.

m) The clear ſolution by ſulphuric acid (*l*) was now combined with the requiſite quantity of vegetable alkali, and by ſlow evaporation made to cryſtallize. It conſtantly yielded, until the end, regular cryſtals of alum. The laſt

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laſt remaining liquor, which conſiſted only of a few drops, I dried to a ſlimy conſiſtence, which, upon dilution with water, ſtill depoſited ½ grain of *ſiliceous earth*.

n) After all the cryſtals of alum, collected from the ſeveral liquors, had been re-diſſolved in boiling water, I precipitated their earth by carbonat of pot-aſh, waſhed, and dried it. But as the aluminous earth is much diſpoſed, even after the moſt diligent edulcoration, firmly to retain a portion of the ſalts, that before were combined with it, more eſpecially the vegetable alkali, whereby its own weight is neceſſarily increaſed; I took care to reſtore it in its true purity, by affuſing upon it twelve times its weight of diſtilled vinegar, digeſting it for ſeveral hours with this fluid; then adding as much cauſtic ammoniac as would ſaturate the acetic acid to exceſs; and laſtly, by a perfect edulcoration of the precipitated *alumine*. When it was afterwards deſiccated and ignited, its weight was found to be 84 grains.

o) At laſt, the *ſiliceous earth* was put to trial. For this purpoſe I heated it to redneſs with four times its weight of mild vegetable alkali, and poured water on the maſs which was obtained. It was completely diſſolved, leaving only a ſlight portion of a ſlimy reſidue; and depoſited again, during ſaturation with muriatic acid, the ſiliceous earth in its uſual form.

Thus the decompoſition of the adamantine ſpar was fully effected; and every uncertainty reſpecting the true nature of its conſtituent parts, that had remained after its firſt examination, is totally removed.

Hence, when we reflect that the magnetic iron, diſſeminated in the Chineſe adamantine ſpar, is merely to be conſidered as a foreign ſubſtance mingled with it, and therefore cannot be conſidered as a conſtituent part, the following will be the *conſtituent parts of adamantine ſpar*, together with their proportions in the *hundred.*

Alumine	*n*)	. . . . .	84,
Oxyd. of iron . .	*l*)	. . . . . .	7,50
Silex	*f*)	4½	
	h)	3	
	l)	9	
	m)	½	
		17	
From which ſubtract	*b*)	10½	
There remain . .		6½	6,50
			98
Loſs . .			2
			100

B.

Decompoſition of the Adamantine Spar from Bengal.

THE *Bengal Adamantine Spar*, or *Corundum Stone*, differs from the Chineſe; *firſt*, in containing no interſperſed magnetic iron, of which only now and then ſome few grains adhere to its external ſurface; and, *ſecondly*, in this, that the ferruginous part, belonging to its chemical mixture, is leſs conſiderable. For this reaſon the whitiſh grey colour of that ſtone is brighter, its thin lamellas more tranſparent, and, as it appears, the hardneſs of the ſtone is in ſome degree greater.

a) When pounded in the ſteel-mortar, it afforded a white powder, inclining to pearl-grey. One *hundred* grains of it, triturated with water in the flint-mortar, I found, after drying and ignition, to have increaſed 11 grains in weight.

b) Upon theſe 100 grains, four ounces of cauſtic lixivium, containing one half its weight of cauſtic alkali, were affuſed in the ſilver crucible; and the fluid evaporated to dryneſs. The maſs being then ignited for three hours, with the neceſſary precaution, it was again ſoftened by drenching it with water, and afterwards filtered. There remained a grey-white reſidue, weighing 47 grains when dry.

c) The alkaline fluid (*b*) let fall, during ſaturation with muriatic acid, a copious, white, and looſe earth; which was immediately re-diſſolved by a ſlight exceſs of the acid.

d) The above-mentioned 47 grains of earth (*b*) completely diſſolved in the muriatic acid. When this ſolution was mixed with cauſtic ammoniac, it afforded a ſlimy and very puffy precipitate. Mild ammoniac was then added to the liquor, which had been immediately ſeparated from this precipitate by filtering, but it produced no farther precipitation.

e) I then put into cauſtic lye the ſlimy precipitate (*d*), moiſt as it was, and digeſted them together. The mixture aſſumed the appearance of a thickiſh ſolution of gum-arabic. On adding more cauſtic lye, the whole was diſ-

ſolved

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ſolved into a limpid liquor, except ſome brown flocks, which, in the dry ſtate, conſiſted of 2¼ grains.

f) Muriatic acid being affuſed upon this flocculent precipitate (*e*), a ſmall portion of *ſiliceous earth* ſeparated, and cauſtic ammoniac precipitated from the clear ſolution an *oxyd of iron*, weighing, after ignition, 1¾ grain.

g) From the alkaline ſolution (*e*), the muriatic acid threw down a quantity of ſlimy earth, which was entirely rediſſolved by a ſmall over-proportion of that acid.

h) Both the ſolutions (*g*) and (*c*), were next united and precipitated by carbonated pot-aſh in a boiling-heat, and the dried precipitate was again diſſolved in dilute ſulphuric acid. When this ſolution, after the addition of a ſufficient quantity of vegetable alkali, had been evaporated to the point of cryſtallization, it readily afforded clear and regular cryſtals of alum, or ſulphat of alumine.

i) The remaining part of the ſolution in ſulphuric acid (*h*) thickened ſpontaneouſly to a clear jelly, on ſubſequent evaporation. This gelatinous matter, after being digeſted with an abundant quantity of water, and repeatedly agitated, again liquefied by degrees. Upon this, ſome *ſiliceous earth* ſubſided; which, when ſeparated by means of a filter, dried up in a raiſed temperature, in the form of tranſparent ſhining grains. It was levigated, together with the foregoing (*f*), and once more boiled with ſulphuric acid. When dried again, and ſubjected to a red-heat, its weight amounted to 15½ grains.

k) The above ſolution in ſulphuric acid (*i*), was then evaporated for further cryſtallization. It continued to the end to yield ſucceſſively regularly cryſtallized ſulphat of alumine: but the very laſt portion was ſtill contaminated with *ſiliceous earth*, amounting to 1 grain after ignition.

l) All theſe ſeveral portions of alum were diſſolved in water, and precipitated in a boiling heat by carbonat of pot-aſh: and when the earthy precipitate which they afforded had been depurated by means of acetic acid, as explained in the preceding ſection, they gave 89½ grains of ignited *aluminous earth*.

Therefore, the products obtained by the decompoſition of the *Adamantine Spar from Bengal* conſiſt of

Alumine	*l*)		89,50
Oxyd of iron . . .	*f*)		1,25
Silex	*i*)	15½	
	k)	1	
		16½	
Subtract	*a*)	11	
Remain	. .	5½ . . .	5,50
			96,25
Loſs . .			3,75
			100

The very predominant proportion of the aluminous over the ſiliceous earth, exhibited by this decompoſition of both varieties of the adamantine ſpar, affords a new proof, that alumine is ſuſceptible of a greater coheſive power than ſilex is poſſeſſed of. Hence nature may form ſtones of extreme hardneſs almoſt entirely from aluminous earth; of which my ana-

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lyſis of the *Sapphire* will give, in the ſequel, a very ſtriking inſtance. On the contrary, it is evident that this does not hold good with reſpect to the ſiliceous earth, as appears from *rock-cryſtal*, its pureſt form; for, how inferior is this laſt in hardneſs to the ſapphire, as well as to the adamantine ſpar!

On analyſing the Chineſe adamantine ſpar, we find that it was ſiliceous earth that remained, when muriatic acid was poured upon that portion, which was not diſſolved by the alkali during ignition. But, on analyſing the Bengal diamond-ſpar, this earth did not appear before the ſolution of the aluminous earth in ſulphuric acid was prepared for cryſtallizing by evaporation; and at that period this acid cauſed it to coagulate into an uniform, colourleſs, gelatinous ſubſtance. This laſt circumſtance is frequently attended by a phenomenon which ſeldom occurs, and is quite different from thoſe which we uſually obſerve on the efloreſcing of ſalts. It is, that the maſs, when coagulated to a clear jelly, branches out in ſeveral places, and forms ſeparate, unconnected figures, often in the ſhape of four, five, and ſix, ſided longiſh pyramids, and often merely as conical points.

Similar phenomena take place, whenever the aluminous earth has entered into intimate union with a ſmall portion of the ſiliceous, as will be ſeen by the following experiment:—I mixed 2 drachms of liquor of flints, the ſiliceous earth of which amounted to 10 grains, with 2 ounces of a ſolution of alumine in cauſtic lye; and ſaturated the mixture with muriatic acid. The earth, thus precipitated, again diſſolved into a limpid liquor, on the affuſion of a ſmall exceſs of acid. When a ſecond time precipitated by carbonat of pot-aſh, and dried, it weighed 70 grains. I then poured upon it dilute ſulphuric acid, and found it entirely diſſolved, without depoſiting the ſiliceous earth with which it was combined. After being in ſome degree evaporated, part of the ſolution ſhot into ſeparate cryſtals of alum; and the remaining part coagulated in the form of a clear jelly, on the ſurface of which, after ſome days, cryſtalline pyramids ſprouted out. And when I had afterwards digeſted this jelly with a large quantity of water, the ſiliceous earth ſubſided; and, being waſhed and ignited, it weighed again very nearly 10 grains.

However, this jelly, which is frequently colourleſs, and is formed by a ſolution of ſulphat of alumine, in intimate chemical combination with finely diſſolved ſiliceous earth, and gently evaporated, ſhould not be confounded with the coagulum, which always takes place whenever the ſolution of aluminous earth in ſulphuric acid has not been blended with the quantity of pot-aſh requiſite to the formation of perfect cryſtals. This laſt forms an opake maſs, of a foliated texture, and ſoft, greaſy conſiſtence.

It yet remained to enquire into the cauſes which rendered my firſt analyſis of the adamantine ſpar ſo very difficult. That one day is improved by another, is a truth which any attentive chemiſt has often had opportunity to experience in a very conſpicuous manner. The method of preparing hard ſpecies of ſtones, recommended by *Marggraf*, *Bergmann*, and others, in order to weaken the coheſion of their parts, conſiſts in igniting them, mingled with a mild fixed alkali. But when I obſerved, that this way of preparing them would not anſwer the purpoſe in moſt of the ſtones belonging to the claſs of gems; and when I conſidered that, in the ſtrict ſenſe, it was only the portion of alkalis free from carbonic acid, which is active in this operation, I tried to ſubſtitute cauſtic alkalis to the carbonated, and found that, by their aſſiſtance, I attained my end with greater facility and certainty. The application cauſtic alkalis, in the dry ſtate, is, nevertheleſs, attended with ſeveral inconveniences. One, and not the leaſt of them, is, that by triturating them with the body to be ſubjected to analyſis, no very accurate mixture will be obtained. Another circumſtance, which embarraſſed my firſt analyſis of the adamantine ſpar, is, that in every attempt I ſubjected it to ignition in a briſk fire, with the view of aſcertaining immediately the quantity of any portion which remained undiſſolved, or which was precipitated from its ſolution. But in this way the ſtone was rendered progreſſively more incapable of farther ſolution; and not only its ſolubility, in ſo far as it had been promoted by ignition with alkali, but alſo the advantage obtained in leſſening the coheſive force of its conſtituent parts, have been again loſt.

How greatly the decompoſition of the harder gems is promoted by the uſe of cauſtic fixed alkalis in the liquid ſtate, combined with the other requiſite methods of treatment, may be proved by the ſecond analyſis of both the Chineſe and Bengal adamantine ſpars.

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IV.

EXAMINATION

OF THE

ORIENTAL SAPPHIRE.

It ſeems to be yet doubtful, whether the modern *ſapphire* be the ſame gem which the ancients have denoted by this name. For we do not perceive in our ſapphire the diſſeminated golden points, mentioned by them as one of its eſſential characteriſtic marks; whence *Theophraſtus*[*] calls it χρυσόπαστος, and *Epiphanius*[†], χρυσοστιγής. It is, however, certain, from a paſſage of *Pliny*, that the ancients did not underſtand by it the κυανος, or *lapis lazuli*, which uſually contains interſperſed ſpeckles of a golden luſtre; but they have well diſtinguiſhed both ſpecies of ſtones. *Ineſt ei* (Cyano) *aliquando et aureus pulvis, non qualis in ſapphirinis. Sapphirus enim et aureis punctis collucet.* Plinius, libr. 39. c. 9.

The gem that we call *ſapphire*[‡] is remarkable by its blue colour, which is ſo very pleaſing to the eye, by its extreme hardneſs, and the high brilliancy which it ſhews when poliſhed. Its ſpecific gravity I have found to be 3,950, in thoſe ſpecimens, which were the ſubject of the following analyſis, and conſiſted of clear, longiſh-round, abraded grains, of a pure azure colour.

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[*] de Lapidibus.

[†] de XII. gemmis, quæ erant in veſte Aaronis.

[‡] For the ſake of the leſs informed, I add, (perhaps not quite ſuperfluouſly) that the foſſil, which is ſold by Dutch druggiſts for

According to the ſtatement of the conſtituent parts of the ſapphire hitherto given, and grounded on *Bergmann's* analyſis, an hundred parts of it are ſaid to contain:

35	*Silex*
58	*Alumine.*
5	*Lime.*
2	*Iron.*

But the following analyſis, begun and ended with the greateſt poſſible accuracy and precaution, will ſhew that the above ſtatement was very incorrect.

a) *Hundred* grains of ſapphire, previouſly pounded to a moderately fine powder in a poliſhed ſteel mortar, were moſt finely triturated with water in a grinding-diſh of flint. When this ſapphirine powder had been dried, carefully collected, and ignited, I obſerved, that its weight had increaſed 12½ grains from the ſiliceous earth of the grinding veſſel.

b) Two ounces of muriatic acid were poured upon theſe 112½ grains in a phial ſo as to cover them, and the whole was repeatedly digeſted with a moderate heat. The filtered acid, mixed with the edulcorating water, was then

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for *ſapphire*, in the ſhape of ſmall, heavy, black-grey, and internally reſplendent grains, and which, ſince the belief in the medicinal virtues of gems, has loſt ground, is now kept in the ſhops merely as an uſeleſs drug, is nothing elſe but *magnetic octahedral iron*, which in Ceylon accompanies the ſapphire, hyacinth, and other gemmeous ſtrata, and, together with thoſe ſtones, is collected by waſhing off the ſand.

ſaturated, in a boiling heat, with mild alkali prepared from tartar, by which there ſeparated yellow flocks, weighing two grains when dry. Theſe being again diſſolved in muriatic acid, and precipitated by cauſtic ammoniac, I tranſferred the precipitate, while yet moiſt, into boiling cauſtic lixivium. It depoſited *oxyded iron*, which, after ignition, weighed *half* a grain. The aluminous earth, taken up by the cauſtic lye, was again ſeparated from it, and found to weigh *one* grain.

c) After this extraction by muriatic acid, as much cauſtic lye was affuſed on the ſapphirine powder, placed in the ſilver crucible, as was neceſſary to make the cauſtic alkali, contained in it, amount to ſix times the weight of the powder. It was next evaporated in a ſand-heat, till the maſs was dry; upon which the crucible was placed in the furnace, ſurrounded with charcoal, and ſubjected to a red heat for two hours. The contents of the crucible returned from the fire in the form of a whitiſh, looſe, and friable maſs.

d) This maſs was ſoftened with hot water, and put on the filter. There remained a bluiſh-grey, ſlimy reſidue, which, being dried, gave a powder of little coheſion, weighing 34½ grains. On adding muriatic acid, it readily diſſolved; but congealed ſoon after to a turbid jelly. By dilution with water, and digeſtion, ſome earthy particles were depoſited, which, after waſhing and drying, amounted to 14 grains.

e) When theſe flocculent particles had been removed, the muriatic ſolution was ſaturated with cauſtic ammoniac; and the reſult was an intumeſced, tranſparent precipitate, which, being previouſly edulcorated, was digeſted, while yet moiſt, in cauſtic lye. It readily diſſolved in it; with the exception of a few brown flocks, which, when collected and ignited, weighed one fourth of a grain, and were *oxyd of iron*.

f) The alkaline ſolution *(e)* was decompoſed by muriatic acid; and the precipitate which it afforded re-diſſolved by a ſlight exceſs of that acid. Upon this, the earth was again precipitated by mild vegetable alkali, in a boiling heat. The weight of the earth obtained in this part of the proceſs was 16 grains, after it had been waſhed and dried.

g) In the ſame manner I combined with muriatic acid the preceding alkaline ſolution *(d)*, obtained by ſoftening the ignited maſs. There reſulted from it a copious white precipitate; but which was again totally diſſolved, by a ſlight over-ſaturation with muriatic acid. The earth was then precipitated afreſh by mild vegetable alkali, aſſiſted by a boiling heat; and was found to weigh 289 grains, when waſhed and deſiccated.

h) To this earth I added the above 16 grains *(f)*, as alſo the one grain of *(b)*; and poured upon the whole dilute ſulphuric acid. The ſolution, which was eaſily brought about in a moderate temperature, again depoſited *eight grains* on cooling.

i) Theſe eight grains, together with the 14 of *(d)*, being then mixed with ſix times its quantity of cauſtic lye, were inſpiſſated, and heated to redneſs. The maſs, thus obtained, and afterwards liquefied in water, left, on filtering, a grey reſidue, weighing 17 grains after deſiccation, which ſoon were diſſolved by the affuſion of ſulphuric acid, leaving ſome few, inconſiderable particles behind. The alkaline ſolution, when ſaturated with muriatic acid, continued at firſt limpid; but it depoſited *four grains* of ſiliceous earth, when evaporated in a warm temperature.

k) I now mixed the ſolutions in ſulphuric acid, mentioned at (*b*) and (*i*); added to them a proportional quantity of carbonated pot-aſh, and, by gentle evaporation, cauſed them to ſhoot into cryſtals. At firſt, fine, pure, and regular cryſtals of ſulphated alumine were formed: but the remaining liquor, while further evaporating, congealed into a clear, gelatinous matter, without any diminution of its tranſparency. Having poured upon it a quantity of water, I ſubjected it to continued digeſtion, ſtirring it now and then. By this management I effected the thorough ſeparation of the finely divided ſiliceous earth, which was the cauſe of the coagulation; inſomuch, that I was enabled to collect it on a filter. This *ſiliceous earth*, carefully collected, together with the above four grains (*i*), weighed 11¼ grains.

l) The remaining ſulphuric ſolution, freed from its ſiliceous contents, was now ſet to cryſtallize. However, the laſt portions of alum indicated, by their lemon-yellow tinge, that they ſtill contained ſome metallic ſubſtance. In conſequence of this, I re-diſſolved them in water, together with the few reſidual drops of their mother-liquor, and combined them with pruſſiat of pot-aſh (blood-lye). A blue precipitate ſubſided; but in ſo ſmall a quantity, that the *portion of iron*, thus ſeparated, could hardly be eſtimated at one fourth of a grain. The ſupernatant fluid, freed from it, afforded pure ſulphat of alumine to the laſt drop.

m) The cryſtals of alum, obtained in the ſeveral foregoing operations, being dried on a porcelain ſaucer in open air, amounted in the whole to 856 grains. They were then diſſolved in boiling water, decompoſed by carbonat of pot-aſh in the heat of ebullition, and the precipitated earth was edulcorated and dried. But, in order to free this earth perfectly from thoſe ſaline particles, which ſtill adhered obſtinately, and augmented its weight, I ſubjected it to gentle digeſtion, with ſix ounces of diſtilled vinegar. Which done, I neutralized the acetic acid by cauſtic ammoniac; edulcorated afreſh the *aluminous earth*, then precipitated, and laſtly, expoſed it to a briſk red-heat, after drying. It weighed now 98½ grains.

n) It ſtill remained to examine the edulcorating water. Being evaporated to dryneſs, and the reſidue re-diſſolved in little water, there remained a ſlight portion of grey earth, which, when examined by ſulphuric acid, proved to be calcareous. The ſolution yielded, during evaporation, ſelenitic cryſtals; which, when carefully collected, weighed 1½ grain, the *calcareous* earth of which ſhould be eſtimated at one half grain.

What principally demands our conſideration, in the reſult of this analyſis, is the remarkable and unexpected circumſtance of the total abſence of the ſiliceous earth, from among the conſtituent parts of the ſapphire. For the 11¾ grains of ſilex which were obtained (*k*), muſt undoubtedly be aſcribed merely to the flinty triturating veſſel, from which the ſapphire had, on grinding, abraded 12½ grains (*a*), and at the ſame time had united with it ſo intimately, that I could not recover it without great difficulty, and even not without a ſmall loſs of three fourths of a grain.

Hence, the following alone can be reckoned among the conſtituent parts of the ſapphire, procured by decompoſition:

Alumine			98,50
Oxyd of iron	*b)*	½	1,
	c)	¼	
	l)	¼	
Lime	*n)*		0,50
			100.

Since on analyſing foſſils, even with the moſt cautious management, there is always ſome unavoidable loſs, it is probable, that the preſent perfect agreement of the ſum of theſe conſtituent parts, with the original weight of the ſapphire employed, is merely accidental. And the reaſon of this agreement muſt be ſought for, in the variable ſtate of dryneſs, communicated to the aluminous earth by heating it to redneſs.

Whence, ſubtracting the unimportant, and perhaps only caſual portion of calcareous earth, as well as the ſlight quantity of ferruginous matter, we find in the ſapphire, the nature of which is now developed, nothing elſe than a ſimple aggregate of pure aluminous earth.

But, what a high degree of coheſive power, and moſt intimate chemical combination, muſt nature be able to command, in order to be capable of transforming ſuch a common ſubſtance, as the *aluminous earth*, into a body, ſo eminently diſtinguiſhed and ennobled, as we find the *ſapphire* to be, by its hardneſs, denſity, brilliancy, and reſiſtance to the actions of acids and fire, as well as to natural decay in the courſe of all-conſuming time!—It is, therefore, not the *identity*, or preciſe ſameneſs of the conſtituent parts alone, but alſo the *peculiar nature of their chemical combination*, which conſtitutes the *metaphyſical eſſence* of the products formed from them by nature.

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V.

EXAMINATION

OF THE

CAT'S-EYE.

The ſpecies of precious ſtones, known by the name of *Cat's-eyes*, has received that denomination from its property of reflecting, in certain directions, a changeable whitiſh effulgence, in which it reſembles the eyes of a cat.

As this ſtone is ſtill a rarity in Europe, the deſcription of its external characters, met with in the lateſt introductions to Mineralogy, could only be taken from the poliſhed ſpecimens which are brought to us from *Ceylon*. As I have in my collection rough cat's-eye from the coaſts of *Malabar*, for which I am indebted to the kindneſs of *Francis Greville*, Eſq. in London, and which, beſides, is one of i[illegible] more unuſual varieties, I think the following addition to the deſcriptions of its external characters, already publiſhed, will not be uſeleſs.

The largeſt ſpecimen conſiſts in a fragment, notably quadrangular, of *one* inch in *length*, three-fourths of an inch in *breadth*, three-fourths ditto in *height*, and three and a half drachms in weight. Its croſs-fracture exhibits a brown-red colour of various ſhades, a moderate greaſy luſtre, and minute ſharp-edged prominences. On the longitudinal fracture, its colour is lighter, its luſtre ſtronger, and it reflects variegated yellowiſh rays of light; at the ſame time, that an imperfectly foliated texture, ſpreading in various directions, is perceivable. On two contiguous ſides it ſtill retains its natural ſurface, or cruſt, which is formed lengthways of convex, roundiſh ſtriæ; and its colour, which was at firſt brown-red, has faded into a dull browniſh-yellow. Its edges and ſmall ſplinters alone are faintly tranſparent.

I found the ſpecific gravity of this rough cat's-eye to be 2,625; whereas that of the whitiſh, greeniſh, and yellowiſh ſpecimens from Ceylon is 2,660.

In the *Eſſay on the Habitudes of ſeveral Stones and Earths in ſtrong Fire*, I have already ſhewn that the cat's-eyes are perfectly infuſible in the ſtrongeſt degree of heat produced in the porcelain-furnace; therefore I ſhall at preſent mention only the change which they undergo in a weaker fire. For this purpoſe I ignited to redneſs in a crucible ſome of the common poliſhed cat's-eyes, of a greeniſh and greyiſh-white colour, and quenched them in cold water. I found them afterwards abſolutely unaltered in form, hardneſs, and ſplendour; but they were rendered totally opake, and acquired an extremely fine marbled jaſper-like appearance, variegated with brown, reddiſh, grey, and white ſpots.

A.

a) *Two hundred* grains of finely levigated *Cat's-eyes from Ceylon*, were mingled with 400 grains of carbonat of ſoda (mild mineral alkali), and the blended maſs was expoſed in a ſilver-crucible to gentle ignition for four hours, but without urging the heat to fuſion. In the next place I ſoftened the maſs with water; ſaturated it to exceſs with muriatic acid; and ſuffered it to ſtand for ſome time in digeſtion. A conſiderable quantity of *ſiliceous earth* then ſeparated, which was collected on the filter, waſhed, dried, and laſtly expoſed to a ſtrong red-heat. In this ſtate it weighed 189 grains.

b) The muriatic ſolution, mixed with the edulcorating water, and concentrated by evaporation, was ſaturated while yet hot with carbonated ſoda; and I obtained a precipitate, which, when waſhed and dried, weighed 15 grains.

c) Theſe entirely diſſolved, with efferveſcence, in the muriatic acid. Only a ſlight portion of *ſiliceous earth* remained, which after ignition amounted to one grain.

d) After the grain of ſiliceous earth had been ſeparated, cauſtic ammoniac was added to the ſolution. A yellowiſh-white, ſlimy precipitate was thrown down; which being immediately ſeparated by filtration, waſhed, and afterwards diſſolved, while yet moiſt, by cauſtic lye, left behind an *oxyd of iron*, weighing one half grain, when waſhed and ignited.

e) I then, by means of muriatic acid, ſeparated the earth taken up by the cauſtic lye; but being re-diſſolved by a ſlight exceſs of this acid, it was again precipitated by carbonat of ſoda. When edulcorated, and diſſolved in ſulphuric acid, it ſhot into cryſtals of *alum*. This ſulphat of alumine was then diſſolved in water, and its earth again precipitated by carbonat of ſoda. This alumine, when edulcorated, and ignited after deſiccation, was found to weigh 3½ grains.

f) The liquor which remained, after the precipitation had been effected by cauſtic ammoniac (*d*), was then combined in a warm temperature with mild mineral alkali; by which treatment, *calcareous earth* ſubſided, which formed ſelenite (ſulphat of lime) with ſulphuric acid. The lime thus ſeparated from this compound, and ignited, weighed three grains.

Since, therefore, 200 grains of theſe cat's-eyes afforded

Silex	*a*)	189	190
	b)	1	
Alumine	*e*)		3½
Lime	*f*)		3
Oxyd of iron	*d*)		½
			197 grs.

it follows, that it contains in *one hundred*,

Silex	95
Alumine	1,75
Lime	1,50
Oxyd of iron	0,25
	98,50
Loſs	1,50
	100

B.

a) *Hundred grains* of the crude *red cat's-eye* from *Malabar*, deſcribed as above, yielded a grey friable maſs; after being finely pulverized, mingled with 300 grains of cauſtic pot-aſh, and ignited, but without fuſion, for an hour in the ſilver crucible. It ſoon diſſolved in water, and formed a turbid liquor. Upon ſuper-ſaturating it with muriatic acid, and ſubſequent digeſtion and filtration, there remained a delicate, white *ſiliceous earth*, which, after waſhing and drying, amounted to 115 grains, but after half an hour's ignition weighed only 93 grains.

b) The muriatic ſolution (*a*), mixed with the waſhings, and previouſly concentrated by evaporation, was then precipitated by carbonated pot-aſh, in the heat of ebullition. The yellowiſh precipitate, which ſubſided, weighed 8½ grains after deſiccation.

c) Theſe 8½ grains completely diſſolved in muriatic acid. Cauſtic ammoniac threw down from this ſolution a ſlimy earth; which only partially diſſolved in the cauſtic lixivium, with which it had been digeſted, and left five grains on the filter.

d) When the earth, taken up by the cauſtic alkaline lye, had again been ſeparated from it, and waſhed and ignited, its weight amounted to two grains. It alſo afforded *cryſtals of alum*, on being treated with ſulphuric acid.

e) The above five grains (*c*), digeſted with ſulphuric acid, ſtill depoſited *ſiliceous earth*, which, having been ex-

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poſed to a red-heat, weighed 1½ grain. The ſolution, freed from this earth, whilſt evaporating, yielded *ſelenite cryſtals*. The yellowiſh liquid, rinſed off from them with dilute or weak ardent ſpirit, and combined with pruſſiat of pot-aſh, produced a deep blue precipitate; the quantity of which was ſo ſmall, that the *oxyd of iron* thus indicated could not with propriety be eſtimated higher than at one fourth of a grain. Mild alkali ſtill ſeparated from the remaining liquor an inconſiderable portion of alumine.

f) Mild vegetable alkali, added at a raiſed temperature to the fluid, from which the cauſtic ammoniac ſeparated the above-mentioned muddy precipitate (*c*), threw down another portion of earth, which united with ſulphuric acid into ſulphat of lime. The *calcareous earth* contained in this ſelenite, as alſo in that of (*c*), was reproduced, or ſeparated from its accompanying acid, by boiling with a ſolution of mild alkali; and its quantity was found, after ignition, to amount to 1½ grain.

According to this analyſis, the conſtituent parts of this red variety of cat's-eye, conſiſt in the *hundred* of

Silex	*a*)	93	94,50
	c)	1½	
Alumine	*d*)		2,
Lime	*f*)		1,50
Oxyd of iron	*e*)		0,25
			98,25
		Loſs	1,75
			100

Therefore, this *proportion of the conſtituent parts*, which in both varieties is to be conſidered as perfectly conſtant, together with their *abſolute infuſibility*, (not to mention the difference in the external character) afford ſufficient reaſon for diſtinguiſhing *cat's-eye* from *fel-ſpar*, under which this foſſil has been claſſed by ſeveral Mineralogiſts.—On the contrary, it would be more proper, in my opinion, to claſs it with the opals; among which alſo it was formerly reckoned under the names of *Pſeudopal*, *Cat's-eye-opal*.

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VI.

ANALYSIS

OF

CHRYSOBERYL.

THE *Chryſoberyl*, found in the Braſil, paſſed for a variety of the Chryſolite, until M. *Werner*, Counſellor of the mines, was induced, by a more accurate compariſon of their reſpective external characters, to ſeparate the former from the latter; and to range it in the mineralogical ſyſtem as a diſtinct ſpecies, with its preſent denomination. This Chryſoberyl, however, muſt not be miſtaken for the *Chryſoberyl of the ancients*, which really was the ſubſtance indicated by this name; that is to ſay, the *golden-yellow beryl*; as may be concluded from its deſcription, given by *Pliny*. Libr. XXXVII. Cap. V. *Probatiſſimi ſunt ex iis*, (namely Beryllis), *qui viriditatem puri maris imitantur. Proximi, qui vocantur* Chryſoberylli, *et ſunt paulo pallidiores, ſed in aureum colorem exeunte fulgore.*

The modern chryſoberyl has hitherto been met with only in ſhivery, looſe, rounded grains *, of the ſize of ſmal-

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* *Geſchiebe* in German. *Rachill* by the miners; or ſuch looſe, ſmall, ſhivery ſtones, as moſt commonly lie on the top of the rock, or immediately under the vegetable earth. See *Hooſon's Miner's Dictionary.*—Tranſl.

ler

ler and larger peas, of a pale-yellow colour, inſenſibly verging to green. The ſurface of theſe grains, which is ſomewhat rough, ſtrongly glitters, and uſually reflects variegated colours, like moonſtone (adularia). But the fracture of chryſoberyl poſſeſſes a great ſplendour, which, in conjunction with a very conſiderable hardneſs, gives it a high brilliance when poliſhed: and hence it may eaſily be confounded with the yellow diamond. Some few ſpecimens exhibit ſome remaining traces of an originally cryſtalline figure.

The ſpecific gravity of this ſtone I have found to be 3,710; which therefore agrees with that mentioned by *Werner*, from 3,698 to 3,719, and is preciſely the mean between theſe two extremes.

The firſt analytical attempts upon it, which I made before I was acquainted with thoſe ſkilful proceſſes which I learned from later experiments, gave me a good deal of trouble, and at the ſame time deſtroyed a conſiderable part of my ſtock of theſe ſtones. But I paſs them over, and confine myſelf merely to that analyſis, the reſult of which was the complete decompoſition of the chryſoberyl.

a) *Hundred grains* of chryſoberyl, previouſly reduced to a moderately fine powder, by pounding them in a mortar of poliſhed ſteel, were levigated with water to perfect fineneſs in the flint grinding-diſh. After the powder had become dry, I ſubjected it to gentle ignition, for the purpoſe of freeing it from all moiſture. However, its weight was increaſed 13 grains.

b) Upon theſe 113 grains, introduced into a ſilver-crucible, I poured ſo much cauſtic lixivium, that the proportion of alkali which it contained amounted to 800 grains, and evaporated the liquid again till the maſs was dry. Upon this I placed the crucible with its contents in a wind-furnace, on a ſtand of porcelain clay, ſurrounding it with coals. Attention was carefully paid to prevent the maſs, which greatly ſwelled in bulk, from flowing over the veſſel. The heat applied was at firſt rather low; but it was gradually urged until the maſs became red-hot. In this degree of heat it was kept for two hours; but it did not enter into actual fuſion.

c) When this maſs had cooled in ſome degree, I ſoftened it in the crucible with water, and poured the ſolution upon the filter. When the fluid parts had paſſed through, there remained on the paper a looſe, light-grey powder, which, when edulcorated and dried, weighed 66½ grains.

d) The alkaline lye that had been ſeparated, together with the edulcorating water, was firſt evaporated, to leſſen its bulk, and then ſaturated with muriatic acid. An abundant white precipitate fell down, but was inſtantly and clearly re-diſſolved, by a ſmall exceſs of acid. Carbonat of pot-aſh, added over a low fire, again precipitated this earth; which being waſhed, and dried in a gentle warmth, was looſe, as white as ſnow, and weighed 138½ grains.

e) The light-grey pulverulent reſidue, mentioned at (*c*), amounting to 66½ grains, being digeſted with muriatic acid, left again a reſidue; which, after waſhing, drying, and ignition, weighed 24½ grains, and was found, upon farther examination, to be pure *ſiliceous earth*.

f) This muriatic ſolution (*e*), ſeparated from the ſilex, was next decompoſed, in a boiling heat, by means of cauſtic ammoniac, and the yellowiſh precipitate, thus produced, was edulcorated; and, while yet moiſt, was boiled with cauſtic lye. It entirely diſſolved therein, ſome brown particles excepted. This reſidue was *oxyd of iron*, and weighed, after ignition in a gentle heat, 1½ grain.

g) The alkaline ſolution (*f*) was ſaturated with muriatic acid. The reſult of this proceſs was a white precipitate, which, by a ſlight ſuperſaturation, again formed a limpid ſolution. The earth was then a ſecond time precipitated, by boiling with mild vegetable alkali. Its weight amounted, after deſiccation, to 29 grains.

h) Theſe laſt 29 grains, together with the preceding 138½ grains of earth (*d*), to which I alſo added the two grains, which were collected from the edulcorating water by evaporation, were digeſted with diluted ſulphuric acid. The whole was diſſolved, excepting ſome *ſiliceous earth*, which weighed 4 grains after ignition.

i) When this ſolution, now perfectly clear, was a little evaporated at a low temperature, tender, ſpicular, or ſpear-ſhaped cryſtals, gradually ſeparated from it; which I collected with proper care. They preſented all the marks of ſelenite; and, on decompoſition by a ſolution of carbonat of pot-aſh, in boiling heat, they afforded 11 grains of mild *calcareous earth* (carbonat of lime). This calcareous conſtituent part of the chryſoberyl was, doubtleſs, before contained in the precipitate of (*d*); and, previous to it sfalling down, it was held in ſolution merely by the water, as it was then in the cauſtic ſtate.

k) This ſulphuric ſolution I now combined with the proportion of carbonated pot-aſh requiſite to the formation of alum*; which ſhot, by degrees, into regular cryſtals:

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[*] On the neceſſity of pot-aſh, and its proportion in the formation of alum, ſee *Hildebrandt's paper* in *Nicholſon's Journal*, vol. IV. page 49.—Tranſl.

Towards the end, however, a ſlight portion of *ſiliceous earth* appeared, which, after ignition, was not more than 2½ grains. The weight of all the ſulphat of alumine obtained amounted to 604 grains.

l) This alum was again re-diſſolved in boiling water, and afterwards decompoſed by means of carbonat of potaſh, at the heat of ebullition. After the precipitated earth had been waſhed, dried, and gently ignited, I digeſted it with diſtilled vinegar; which being neutralized by cauſtic ammoniac, the earth was again precipitated by this treatment, and again waſhed, deſiccated, and heated to redneſs. It proved now to be perfectly pure *aluminous earth*, weighing 71½ grains.

We may, therefore, infer, that the conſtituent parts of the chryſoberyl, exhibited by this analyſis, conſiſt in the *hundred*, of

Alumine	*l*)		71,50
Lime	*i*)		6
Oxyd of iron	*f*)		1,50
Silex	*e*)	24½	
	h)	4	
	k)	2½	
		31	
To be ſubtracted	*a*)	13	
Remain		18	18,00
			97
Loſs			3
			100

From comparing the preſent analyſis of *chryſoberyl* with the following decompoſition of *chryſolite*, it is evident how greatly their reſpective conſtituent parts differ, and conſequently, how neceſſary it was to ſeparate them from each other, in the ſyſtematical arrangement of the ſpecies of gems.

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VII.

EXAMINATION

OF

CHRYSOLITE.

THE *Chryſolite* affords a ſingular inſtance of change in names; ſince, at preſent, we call the ſame gem *Topaz*, which the ancients underſtood by the denomination *Chryſolite*; for it is evident, from the following words of Pliny, that the *Topazius* of the ancients is not our modern Topaz; but, on the contrary, the Chryſolite of the preſent times: *Ejus tota ſimilitudo ad porri ſuccum dirigitur. Eſt autem ampliſſima gemmarum. Eadem ſola nobilium limam ſentit: cætera Naxiis cotibus poliuntur. Haec et uſu atteritur. Pliny* Hiſt. Nat. Lib. XXXVII. Cap. VIII.—The cauſe of this change of name is ſo much the more unaccountable, as the denomination Chryſolithus (golden-ſtone) undoubtedly more applies to the Topaz, which is of a golden-yellow colour, than to our Chryſolite, which is green.

The more detailed external deſcription of the *Chryſolite*, given by *Werner** with that degree of accuracy we are entitled to expect from ſuch a maſter, comprehends all, that, in the preſent ſtate of our knowledge, can be ſaid on the natural hiſtory of that ſtone, reſpecting its external characters, and the marks by which it is to be diſtinguiſhed from the other ſpecies of ſtones, with which it has been ſo often confounded. But, on the other hand, an accurate chemical analyſis, and hence alſo the knowledge of its proper place in the mineralogical ſyſtem, have, till now, been ſo much the more wanting: a deficiency which I hope to remove, by now publiſhing the experiments to which I have ſubjected it.

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* *Bergmänniſches Journal, 3d year, 1790, Vol. 2, page 54.*

To remove all doubts, I previouſly mention that the Chryſolites analyſed by me, as well as thoſe from which *Werner* has drawn up their external deſcription, were bought by *John Hawkins*, Eſq. in the Levant, on his travels for promoting the knowledge of Natural Hiſtory, and were ſent to me by him for that purpoſe.

The ſpecific gravity of Chryſolites I have found to agree with the ſtatement of *Werner*, namely, 3,340.

A.

a) I took *two hundred* grains of rough chryſolite, and at firſt bruiſed them in the ſteel-mortar, and afterwards reduced them to a fine powder by trituration with water in the flint grinding-diſh. This powder, when dried by heat, I obſerved had not increaſed in weight. I poured upon it *two ounces* of pure cauſtic lye, the alkaline contents of which amounted to one half of its weight, and evaporated the whole to dryneſs in the ſilver-crucible, and ignited it afterwards for thirty minutes. There remained a friable maſs, which, after cooling, was of a duſky olive-green.

b) When this maſs had been ſoftened with water, the ſolution aſſumed the ſame colour, and a brown, undiſſolved portion fell to the bottom, of a ſlimy appearance. The ſolution being ſaturated to exceſs with muriatic acid, and ſufficiently digeſted, acquired a ſaffron-yellow colour: upon which it was diluted with water, and filtered. A pure ſiliceous earth then remained, which, after ignition, amounted to 72½ grains.

c) The muriatic ſolution, when decompoſed in a boiling ſtate by mild vegetable alkali, prepared from tartar, afforded an abundant, light-brown-red precipitate, which, upon deſiccation, again entirely diſſolved in muriatic acid, and by the affuſion of cauſtic ammoniac, formed a brown-red precipitate; which was directly ſeparated by filtering, then waſhed, and digeſted with cauſtic lye, while yet moiſt. However, only a ſmall portion ſeemed to diſſolve by this treatment.

d) After the undiſſolved matter had been ſeparated from the alkaline ſolution (*b*), I ſuper-ſaturated this laſt with muriatic acid, and added carbonated pot-aſh, for the purpoſe of obtaining a precipitate. However, only a little earth ſeparated, which, when collected, and tried for alumine by ſulphuric acid, did not diſſolve in it; but, on cloſer examination, proved to be *ſiliceous earth*, weighing 3½ grains after ignition.

e) The brown precipitate, which had been digeſted with cauſtic lixivium (*c*), when dry and expoſed to a red-heat, gave 38 grains in weight. It conſiſted of a pure *oxyd of iron.*

iron. The whole was attracted by the magnet. Upon being diſſolved in muriatic acid, and again precipitated by pruſſiat of pot-aſh, it yielded 88 grains of very deep-coloured Pruſſian-blue.

f) The muriated fluid, after the ferruginous contents had been ſeparated from it by ammoniac (*c*), gave a copious white and looſe earth, by adding carbonat of pot-aſh. The mixture having been kept boiling for ſome time, this earth was ſeparated by filtration, well waſhed, and dried. It amounted to 198 grains of *carbonated magneſia* (mild magneſian earth), which I divided into two parts. One half of it was ſtrongly ignited for the ſpace of an hour, and left 39½ grains, which produced a briſk ebullition upon the affuſion of ſulphuric acid. The other half was introduced into dilute ſulphuric acid. It directly afforded a clear ſolution, and pure ſulphat of magneſia (Epſom ſalt), by cryſtallization.

Note. It was by mere accident that, on the precipitation at (*c*) no more ammoniac had been added than was juſt neceſſary to ſeparate the oxyd of iron; ſince otherwiſe, in all caſes, the magneſian earth is alſo precipitated by ammoniac.

According to this decompoſition, the conſtituent parts of the chryſolite ſhould be in the *hundred*,

Ignited *Silex* . .	*b*)	36¼	38
	d)	1¾	
Ignited *Oxyd of Iron*	*e*)	. . . .	19
Ignited *Magneſia*	*f*)	. . . . .	39,50
			96,50
		Loſs .	3,50
			100

B.

B.

For a ſecond analyſis of chryſolite I choſe poliſhed ſpecimens, which, beſides a pure tranſparency, poſſeſſed alſo a brighter colour: whereas the crude chryſolites, employed in the foregoing proceſs, were in ſome parts inclining to brown. As I intended, at the ſame time, to learn whether acids alone were capable of decompoſing this ſtone, without previous treatment with alkali, I made uſe of the ſulphuric acid, according to the manner in which *Marggraf* has employed it for decompoſing the ſerpentine.

a) I poured ten drachms of concentrated ſulphuric acid, mixed with double that quantity of water, upon *two hundred* grains of moſt finely-powdered chryſolite, placed in a retort, and abſtracted again the fluid, in a moderate diſtilling heat, until the remainder in the retort appeared a dry maſs. The liquor which came over, emitted a moderate ſulphureous ſmell. When cold, I collected the maſs from the retort, the upper part of which I cut off, and lixiviated it with boiling water. The ſolution exhibited a greeniſh colour, but ſo faint as to be hardly perceptible.

b) The undiſſolved reſidue was boiled a ſecond time, in a matraſs, with two drachms of concentrated ſulphuric acid, and two ounces of water. After this it was again collected on the filter, waſhed with an abundance of boiling water, deſiccated, and heated to redneſs. It proved to be pure, white *ſiliceous earth*, weighing 78 grains.

c) Both the ſulphuric ſolutions (*a*) and (*b*) were evaporated to dryneſs in a porcelain-ſaucer. The reſidual maſs had a greeniſh-grey tinge: it was firſt gently heated in a porcelain pot, during which operation it emitted ſtrong fumes; and after this it was thoroughly ignited in a briſk fire for the ſpace of one hour.

d) The ignited maſs had then acquired a brick-red colour. It was levigated, lixiviated with hot water, and the red *oxyd of iron*, which it contained, was ſeparated by filtration, and ſubjected to ignition. This oxyd weighed 39 grains: but as, in the preſent ſtate, it was combined with a greater quantity of oxygen than when forming a conſtituent part of the chryſolite, in order to free it from that exceſs, it was immerſed in melted wax, in a ſmall crucible; and, after the wax had been burnt off, the oxyd was kept for ſome time longer in a low red-heat, the veſſel being then covered. Its red colour had now changed into a blackiſh brown; it was alſo readily attracted by the magnet, and weiged 38 grains.

e) After the colourleſs ſulphated ſolution (*d*) had been evaporated for cryſtallization, it yielded, to the laſt drop, pure ſulphat of magneſia. This neutral ſalt being diſſolved, and decompoſed in the heat of ebullition by carbonated pot-aſh, afforded 213 grains of white and looſe *magneſian earth*, the weight of which, after an hour's ignition, was only 87 grains.

From this ſecond analyſis, which exceeds the foregoing in the accuracy of its reſults, it appears that the conſtituent parts of chryſolite, proportioned to each other in the *hundred*, are as follows:

Ignited *Magneſia*	*c*)	43,50
Silex	*b*)	39
Ignited *Oxyd of Iron*	*d*)	19
		101,50

Note. The reaſon why, in the preſent decompoſition, there is a ſlight exceſs of weight in the ſum of the conſtituent parts, inſtead of the uſual loſs in moſt other caſes, undoubtedly depends in the variable degrees of dryneſs which thoſe ingredients acquire on ignition.

In the quarries near *Leutſchau*, in Hungary, we meet with a pale-green ſerpentine, mixed with grey, and croſſed by tender veins of aſbeſtus. It alſo contains, copiouſly diſſeminated, reſplendent grains, of a high green colour, which, in ſome parts of my ſpecimen, exhibit a rhomboid cryſtallization. *Born*[*] and *Fichtel*[†], who have given a more circumſtantial information reſpecting this ſtone, call theſe grains *Chryſolite*. *Fichtel*, however, is uncertain whether they ſhould not rather be conſidered as Chryſopraſe. But this conjecture is too little favoured by the external characteriſtic marks; while, on the other hand, the minuteneſs of theſe grains, and the impoſſibility of ſeparating them from the ſtone, which ſerves them for a matrix, will not admit of a chemical examination. Notwithſtanding this, their preſence in the ſerpentine affords a *geognoſtic* argument for conſidering them as chryſolite, ſince the conſtituent parts of each have been diſcovered to be the ſame.

* * *

A looſe ſtony matter (*rachill*), which is found near *Moldauthein*, in Bohemia, has likewiſe, for ſome time paſt, been held out to be chryſolite: but, on judging from the ſpecimens, rough and poliſhed, which I have ſeen at *Prague*, I cannot conſider them as ſuch; becauſe the external appearance of the rough pieces, and eſpecially the fine air-bubbles obſervable in the poliſhed ſpecimens, are rather an indication of a volcanic product. Herein I alſo find the opinion of *Lindacker*[*] to agree with mine.

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[*] Catal. meth. et raiſon, de la collect. des Foſs. Tom. I. p. 69.

[†] *Mineralog. Bemerk.* v. d. *Karpathen*, I. Th. Wien. 1791, page 60, 61.

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[*] See his *Beitrag zur* Geſchichte der böhmiſchen *Chryſolithe: in den Saml. phyſikal. Aufſätze beſonders die böhm. Naturgeſchichte betreffend.* 2 *Band Dreſden*, 1792.

VIII.

EXAMINATION

OF

OLIVIN.

To the various ſtones which were formerly conſidered as a ſubordinate ſpecies, or rather variety of chryſolite, alſo belongs the foſſil known by the name of *Baſaltic*, or *Volcanic Chryſolite.*

On giving the external deſcription of this ſtone, together with that of the true chryſolite, *Werner* has not only accompanied it with the moſt inſtructive obſervations, but likewiſe, from his *oryctognoſtic* inquiries, he has ſhewn the neceſſity of diſtinguiſhing the *baſaltic* from *true* chryſolite. Whence alſo he conſiders the former as a diſtinct ſpecies, with the name *Olivin*, taken from its colour.

As it is the office of Chemiſtry to aſſiſt the *Oryctognoſtic Science** in the further improvement of its ſyſtem, by communicating certain facts relative to the conſtituent parts of minerals, it is for the Chemiſt to examine whether, and how far, the conjectures reſpecting the eſſential ingredients in any foſſil, inferred from its external properties, are founded in nature: and, conſequently, to determine with what propriety it had obtained the place previouſly given to it in the ſyſtem, on account of thoſe ſuppoſed conſtituent parts.

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* By *Oryctognoſy*, *Werner* underſtands the *ſcientific* knowledge or diſcrimination of foſſils from each other, conſidered as ſimple, that is, not compounded aggregates of various different minerals; and their *ſcientific* arrangement, or *claſſification*, into a regular ſyſtem, according to certain *orders*, *claſſes*, *genera*, *ſpecies*, *varieties*, &c.—Tranſl.

For this reaſon I have thought it expedient to join the analyſis of the Olivin with that of Chryſolite.

FIRST SECTION.

Analyſis of the Olivin; from Unkel.

To diſcover the conſtituent parts of Olivin, I firſt choſe that from the *Baſalt of Unkelſtein*; in which rock it occurs in its perfect and undecayed ſtate, in pretty large cluſters, of a thoroughly equal, pale leek-green colour, and without any admixture of extraneous matters. Its ſpecific gravity was 3,265.

A

a) *Two hundred* grains of finely pulverized Olivin were covered with two ounces of cauſtic lye, the alkaline part of which conſtituted half its weight. After the liquid had been evaporated, the dry maſs was ignited for half an hour.

It aſſumed a grey colour, and was then liquefied or ſoftened with water, and filtered.

b) Upon ſaturation with muriatic acid, the alkaline lixivium let fall a white earth, which, being collected and dried, was boiled with ſulphuric acid. But this earth did not impart any foreign taſte to the acid; and when this laſt had again been decanted off, and ſaturated with mild alkali, it continued clear. Therefore the above earth was of the pure *ſiliceous* kind. When ignited, it weighed 49 grains.

c) The aſh-grey reſidue, ſepatated from the alkaline lye (*a*), coagulated to a thickiſh brown maſs, upon the affuſion of muriatic acid. After this coagulum had been diluted and digeſted with ſufficient water, there remained a copious, light, ſlimy, and brown reſidue, which, upon deſiccation, weighed 152 grains.

d) The muriatic ſolution, ſeparated from this reſidue by filtration, was colourleſs. By the addition of mild alkali, prepared from tartar, it was decompoſed with the aſſiſtance of boiling heat, and 181 grains of a very white, looſe earth, were precipitated.

e) When the brown reſidue, mentioned at (*c*), after trituration, was digeſted with muriatic acid, it diſſolved into a yellow liquid, leaving, at laſt, *ſiliceous earth* behind, weighing 43 grains after ignition.

Note. It was undoubtedly this ſiliceous earth, ſtill intimately united with the ferruginous part of the ſtone, which in (*c*) prevented the muriatic acid from exerting its action on the oxyd of iron: yet this circumſtance, at the ſame time, furniſhed the means of exhibiting, free from iron, that portion of the earth which the acid had diſſolved.

f) The ferruginous portion of the yellow muriatic ſolution (*e*) I precipitated by cauſtic ammoniac. It was then collected and waſhed; and, while yet moiſt, boiled with cauſtic lye. The lixivium was then again ſeparated by filtration, combined with muriatic acid to ſuper-ſaturation, and afterwards precipitated by carbonated alkali. Only a ſmall portion of earth fell down, which, upon trial, proved to be *ſiliceous*, and weighed 4 grains, after it had been expoſed to a red-heat. The liquor remaining, after the precipitation of the iron, was mixed with carbonat of pot-aſh; but no further precipitation nor turbidneſs enſued.

g) The *oxyd of iron*, that was again collected after the boiling with muriatic acid (*f*), was put into melted wax, in a ſmall crucible, and heated to redneſs; after this laſt had been burned off, it obeyed the magnet, and amounted to 25 grains.

h) Upon the above 181 grains of earth (*d*) I poured dilute ſulphuric acid; in which it diſſolved with efferveſcence. When the ſolution had been reduced within a ſmaller compaſs by evaporation, it depoſited minute ſpicular cryſtals, conſiſting of 1½ grain of ſelenite, the pure *calcareous earth* of which is to be eſtimated at ½ grain.

i) The ſolution, on further evaporation, yielded pure ſulphat of magneſia; which, being re-diſſolved, and precipitated at the temperature of boiling, by carbonat of pot-aſh, depoſited a very pure and looſe *magneſian earth*, whoſe weight, after ignition for an hour, amounted to 74 grains.

It follows, from theſe operations, that the conſtituent parts of the Olivin from Unkel are, in the *hundred*,

Ignited

Ignited *Silex* . . .	*b*)	24½	
	e)	21½	. . 48
	f)	2	
Magneſia . .	*i*)	. . . . .	37
Lime . . .	*b*)	. . . . . .	0,25
Ignited *Oxyd of Iron* .	*g*)	. . . . .	12,50
			97,75
		Loſs . .	2,25
			100

B.

With the view of confirming theſe reſults, I undertook another decompoſition of the ſame *Olivin from Unkel*. In this inſtance I treated it immediately with ſulphuric acid, in the ſame manner as I did with the chryſolite, without previous ignition, in conjunction with alkali.

a) I put *two hundred* grains of moſt finely pulverized olivin in a retort, pouring upon them *ten* drachms of ſulphuric acid, together with a ſufficient quantity of water; and again diſtilled the liquid over to dryneſs. Upon this I ſoftened the remaining grey-white maſs with hot water, and boiled afreſh the undiſſolved earth, ſeparated from the fluid, with 2 drachms of ſulphuric acid, and ſufficient water. The liquid, filtered off from the reſidue there left, was added to the firſt ſolution. What remained was mere *ſiliceous earth*, whoſe weight, after ignition, amounted exactly to 100 grains.

b) The ſulphuric ſolution (*a*) left, upon evaporation, a greyiſh-olive-green ſaline maſs, which I evaporated ſtill farther in a porcelain-crucible, urging it at laſt to a red-heat in a ſtronger fire. The maſs retained at firſt its whitiſh colour, but at length it aſſumed a pulverulent ſtate, and turned brick-red. When triturated, drenched with hot water, and filtered, it left a red *oxyd of iron*, which, after being treated with wax and ignited, weighed 24 grains.

c) After the clear ſolution of (*b*) had been evaporated in order to cryſtallize, it ſhot wholly into ſulphat of magneſia: but, when it was re-diſſolved in a moderate proportion of water, ſome cryſtals of ſulphated lime appeared, the quantity of which indicated one half grain of pure *calcareous earth*. Theſe laſt having been ſeparated, the remaining ſolution was decompoſed, by means of carbonated pot-aſh, in boiling heat. The *magneſian earth*, thus obtained, was pure, white, and looſe. When deſiccated at a ſomewhat raiſed temperature, its weight amounted to 188½ grains; but it was reduced to only 77 grains, by ignition for the ſpace of an hour.

By this method of analyſing, which, with regard to magneſian ſtones, is not only the moſt commodious, but alſo indicates the reſults with the greateſt exactneſs, the conſtituent parts of the *Olivin from Unkel* were found to be, in the *hundred*, as follows:

Silex . . .	*a*)	50
Oxyd of Iron .	*b*)	12
Magneſia	*c*)	38,50
Lime . . .	*c*)	0,25
		100,75

Note. The ſame obſervation applies to the agreement of this ſum with the weight of the ſubſtance employed, and the ſlight exceſs, as has been already mentioned, at the end of the ſecond analyſis of chryſolite.

SECOND SECTION.

Analyſis of the Olivin from Karlsberg.

The Olivin from the Baſalt of *Unkel*, employed in the foregoing examination, was, as has been mentioned, in its freſh and unimpaired ſtate: but as moſt olivins ſhew more or leſs evident marks of decay, it ſtill remained to enquire, whether, in thoſe ſpecies of olivin that are more diſpoſed to decay, any difference exiſted in their conſtituent parts. For this inveſtigation I choſe the *olivin* from the Baſalts of the *Karlsberg*, near *Caſſel*, in *Heſſia*. I comminuted it coarſely, and waſhed off with water the yellow iron-ochre that inveſted its ſurface and its chinks. It then conſiſted, for the moſt part, of ſmaller grains of a faint greeniſh-yellow colour, but in part alſo of larger grains, whoſe colour was a ſomewhat freſher leek-green. In theſe latter I obſerved black-grey particles, of a metallic luſtre, imbedded in, or concreted with, their ſubſtance. When I had ſtrongly ignited ſome of theſe upon charcoal, I found that the green ſtony matter of the olivin had thereby become grey, dull, and opake; while the diſſeminated black-grey particles had ſuffered no change. This ſhewed, that they were not minute cryſtals of horn-blende, but iron, and eſpecially of the nature of the ſpecular, or grey iron-ore, becauſe they were not attracted by the magnet.

a) Upon *three hundred* grains of this olivin, finely pulverized, I poured 4 ounces of ſtrong ſulphuric acid, together with 2 ounces of water, and again diſtilled from it the fluid, which emitted a ſlight ſmell reſembling ſulphureous acid, until the reſidue became a dry maſs. The *ſiliceous earth*, remaining after this maſs had been boiled with water, was a ſecond time boiled with half an ounce of ſulphuric acid, and ſufficient water. After this it was collected and ignited. It weighed 156 grains.

b) In order to learn whether *aluminous earth* was one of the extracted conſtituent parts, I took the third part of the whole of the ſulphuric ſolution, and precipitated, by carbonated pot-aſh, at the degree of ebullition, all that it held in ſolution. The freſh precipitate had a dirty, bluiſh colour; and I put it into cauſtic lixivium, as ſoon as it was edulcorated, digeſting it with the lye for ſome time. The mixture was next diluted with more water; the lye, ſeparated from it by filtering, was ſaturated with muriatic acid; and, after a ſlight ſuper-ſaturation, again combined with alkali. But this produced neither a precipitate nor muddineſs.

c) Being thus convinced of the total abſence of aluminous earth, I evaporated the remaining two-thirds of the ſulphuric ſolution (*b*) to a dry ſaline maſs, which I expoſed to a ſtrong red-heat in a crucible, for the purpoſe of decompoſing the ſulphat of iron which it contained. I then re-diſſolved the ignited maſs in water, and ſeparated the red *oxyd of iron* by filtration; which, by ignition with wax, was rendered attractible by the magnet, and weighed, in that condition, 21½ grains.

d) The ſolution, freed from the oxyd (*c*), cryſtallized by degrees into ſulphat of magneſia. When this had again been diſſolved in a ſmall quantity of water, light, delicate, needled cryſtals of ſelenite were left, the quantity of which hardly amounted to ¾ of one grain, which indicates ¼ grain of pure *calcareous earth.* To the diſſolved ſulphat of magneſia, corbonat of pot-aſh was added in a boiling heat; and thus its *magneſian earth was precipitated,* amounting, after ignition, to 75½ grains.

Whence the conſtituent parts of the *Heſſian* olivin, and their reciprocal proportions in the ignited ſtate, conſiſt, in the *hundred,* of

Silex	a)	52
Magneſia	d)	37,75
Oxyd of Iron	c)	10,75
Lime	d)	0,12
		100,62

* * *

From theſe reſults, it is plain that the olivin and chryſolite are very nearly related to each other; and, as the conſtituent parts of each other are ſo much the ſame, and their reſpective proportions not too diſſimilar, it ſeems to me proper that theſe two ſtones ſhould no longer be divided into two different ſpecies; but that the difference, deduced from their external characters, can only juſtify the ſubdividing them into two *varieties* of *one ſpecies.* Moreover, ſince no greater difference appears to take place between them, than, perhaps, that by which the baſaltic horn-blende is diſtinguiſhed from the common, it follows, that the olivin might be entitled to claim its former denomination of *baſaltic chryſolite.*

According to the habitudes of the chryſolite and olivin in the heat of the porcelain-furnace, (mentioned in the firſt Eſſay, n. 25, and 61-64), the former returned from the fire unaltered in form; but the ſecond appeared in concreted grains, which were cemented together by the heat with more or leſs force of adheſion. From this circumſtance I was induced to repeat the experiment with the chryſolite; with this difference, however, that I broke it into pieces of the ſize of the grains of olivin, before I incloſed it in the charcoal. After thoſe pieces had undergone the action of the fire, I found them, like ignited olivin, of an iron-black colour, opake, thinly glazed, and conglutinated. Yet both the glazing and concretion were ſomewhat leſs in degree than what took place in the *Heſſian* and *Greenland* olivins.

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IX.

CHEMICAL EXAMINATION

OF VARIOUS

SILVER-ORES[*].

AT the time when Philoſophical Chemiſtry was yet in its infancy, and when it was not known how to decompoſe natural bodies otherwiſe than by fire, with very few exceptions, the knowledge of the conſtituent parts of the bodies, belonging to the mineral kingdom, could not but be imperfect. Chemiſts were ſatisfied with the products obtained in the dry way, as it is called, and either paid no attention at all to the other ſubſtances contained in theſe bonies, or, confiding in groundleſs hypotheſes, have fancied certain conſtituent parts, of which nothing could be diſcovered by the light kindled by Philoſophical Chemiſtry, the baſis of which is real facts.

Only, while this latter was advancing in its progreſs, the learned began to perceive, and ſeriouſly to attend to this great deficiency of knowledge reſpecting the foſſil kingdom, as well as to the tottering foundation of the mineralogical ſyſtems thereon eſtabliſhed. Accordingly, this part of Natural Philoſophy was enabled, by the laudable exertions of *Schwab*, *Brand*, *Cronſtädt*, *Wallerius*, *Marggraf*, *Scheele*, *Bergmann*, and ſeveral chemiſts now living, to riſe from obſcurity; and chemical mineralogy has now obtained the place, which is due to it among her ſiſter ſciences.

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[*] Read in the Royal Acad. of Scienc. at Berlin.—See the *Collect. of Germ. Treatiſes* of that Acad. Berlin, 1793 and 1794.

Yet, all that has hitherto been done in this ſcience, is nothing more than a ſplendid beginning. Our acquaintance with the conſtituent parts of foſſils is ſtill confined within narrow limits. Not only are we ſtill ignorant of the compoſition of a multitude of foſſils; but, even with reſpect to thoſe, with which we appear to be already acquainted, further confirmation is required: for nothing is more detrimental to the progreſs of a ſcience, than to adopt errors as undoubted and long-eſtabliſhed truths; to transfer them from one ſyſtem, and from one elementary treatiſe, into another, and to multiply them by concluſions which muſt be as groundleſs as the premiſes, from which they are inferred, are falſe.

If, therefore, a ſyſtematical mineralogy, arranged according to the chemical conſtituent parts, (which, as yet, has hardly been eſtabliſhed), is to be ſupported by a more ſolid foundation, and brought nearer to perfection, it is neceſſary that a long ſeries of ſucceſſive analytical experiments ſhould be made. But ſince, for this purpoſe, a ſound chemical knowledge, accompanied by patience, leiſure, accuracy in management and obſervation, as well as a frequent ſacrifice of ſcarce and coſtly foſſils, are required; and ſince thoſe circumſtances do not uſually coincide, this branch of natural ſcience cannot hope for a ſpeedy and plentiful harveſt. It muſt ſtill, therefore, as hitherto, only look for detached and occaſional improvements.

Among the numerous productions of the foſſil kingdom, of which an exact chemical knowledge is yet wanting, the *genus of the ſilver-ores* ſeemed to me to require, in a high degree, a re-examination and amendment. For this reaſon I have ſubjected its chief ſpecies to analytical treatment; the reſults of which are communicated in the following ſections.

FIRST SECTION.

Native Hornſilver, or Corneous Silver-ore. (Hornerz).

(*Vitriolico-muriated Silver-ore*, by *Kirwan.*)

The *Corneous* is remarkable among the rarer *ores of ſilver*, not only from its richneſs, but alſo from the ſubſtance by which nature has mineralized that noble metal.

The name *Hornerz* appears to be of a later date than our knowledge of that ore, ſince ſeveral writers on metallurgy, of the 16th century, have already mentioned it with the appellation of *Glaſerz*; for it is obvious, from the deſcriptions which thoſe authors have given of it, that they did not mean our modern *Glaſerz*, namely, the ſulphurated ſilver-ore. *Mattheſius*[*], noticing ſeveral of its varieties, calls them *white*, *grey*, *yellow*, *green glaſerz*; and ſays, "*it is tranſparent like horn in a lanthorn, and fuſes in the flame of a candle.*"—*Fabricius*[†] mentions a liver-coloured ſilver-ore, "*which in lumps, viewed againſt the light, is obſcurely*

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[*] *Mattheſius* Sarept. 1585. Norimb.

[†] *Fabricius* de rebus metall. Zürch, 1566.

tranſparent like horn, and in ſmall parts is entirely tranſparent like ice."—From this it may reaſonably be conjectured, that the *glaſerz* of the ancients has, in later times, been erroneouſly confounded with our modern one, as this denomination is, indeed, more ſuiting the *hornerz*, or corneous ſilver-ore, than ſilver, mineralized by ſulphur; and, on the other hand, no reaſon can be found for giving that name to the latter.

During the 16th century, in which the Saxon and Bohemian mines yielded vaſt treaſures, the revenues ariſing from this ſilver-ore often amounted to ſeveral hundred marks (8 ounces each): but, in the progreſs of time, it became ſcarcer and leſs known, until the celebrated Saxon maſter of the mines, Mr. *Pabſt of Ohain*, diſcovered it, as it were, anew, and gave it the name *Hornerz*, becauſe reſembling the factitious *horn-ſilver* (muriat of ſilver.)

It occurred formerly at *Joachimsthal*, *Annaberg*, *Schneeberg*, *Freiberg*, and in greateſt quantities at *Johann-Georgenſtadt*. At preſent, it is alſo found in ſome mines of the *Altaic mountains* in Siberia; and, according to *Sage*, likewiſe in the province of *Guamanga* in *Peru*, together with the native ſilver.

With reſpect to external form, I have met with the following varieties of the corneous ſilver-ore,

1) *Maſſive (Derbe)*. As ſuch it has been worked, in the times of its abundance, in the above-mentioned Bohemian and Saxon mines, copiouſly, and ſometimes in pieces of upwards of an hundred marks in weight. There may yet be ſeen, in the electoral-mineral cabinet, at *Dreſden*, a piece of that kind, cut in a cubical form, weighing ſeveral pounds; and alſo a ſmaller one,

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one, which has ſome impreſſions of ſtamps. Both theſe ores are probably remnants of that century, which have been fortunately ſaved. The colour of this corneous-ore is a dirty brown, though its proper hue ſeems to be the pearl-grey, and the brown tinge to ariſe from the interſperſed iron-ochre. It is ſoft; and may, like wax, be cut with the knife into thin chips; is poſſeſſed of a waxen gloſs, and tranſparent on the edges and thin places.

2) In *lamellar pieces (ſchaalig)*, incumbent on meager quarz, in the form of a cruſt; from the *Schlangenberge.*

3) In ſtill thinner layers, in part only incruſting, (*angeſlogen*, or lying ſuperficially), at times accompanied by native gold, or alſo by *lead-ſpar*, or ſpathoſe lead-ore, from the ſame place.

4) *Cryſtallized* in minute regular cubes, of a pearl-grey colour; from *Johann-Georgenſtadt.*

5) In fine *ſcales*, or *flakes*, of a whitiſh colour. In this manner the corneous ſilver-ore, even now, ſometimes occurs at *Johann-Georgenſtadt*, upon brown iron-ochre *Eiſen bräune*).

6) In an *earthy* form, mingled with argil. This is the genuine *butter-milch ſilver* (argillo-muriated ſilver-ore) of the former mineralogiſts, and which *Veltheim** has deſcribed. The ſpecimen which I have ſeen was dug up in the year 1617, on the old St. *George* mountain, at *Andreaſberg*, and is now preſerved at Berlin, in the royal department of the

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* *Crell's* German edition of *Kirwan's* Mineralogy. Berlin, 1765, page 281, ſeqq. in the notes.

mines. It conſiſts of an *aëtitic*, kidney-formed nodule of calcareous ſpar, the cavity of which is filled with this *butter-milch ſilver*, in the form of a deſiccated earth, externally of a ſlate-blue, but of a browniſh white on the recent fracture; with which ore, likewiſe, the outer ſides of the ſpecimen are for the moſt part coated.

7) In grey lime-ſtone, but *imperceptible* to the eye; from *Annaberg*, in Lower Auſtria. This laſt is the foſſil mentioned by *Juſti*[*], under the name of *alkaline ſilver-ore*.

* * *

The following are the principal chemical reſearches that have been made into the corneous ſilver-ore, as well as its eſſential ingredients, and are communicated to the ſcientific public.

1) That of *Lommer*[†], maſter of the mines in Saxony, who has alſo given the beſt information reſpecting the hiſtory and external properties of this mineral. This author eſtimates the argentine portion of this ore, when in pure ſtate, at 28 *per cent.*; but the violet-ore of this kind he ſuppoſes to contain alſo a portion of alkalized ſulphur.

2) *Woulfe*[‡] is of opinion, that he has diſcovered, in the corneous ſilver-ore, beſides the muriatic acid, the ſulphuric, as a mineralizing medium. It is upon the authority of this ſtatement of *Woulfe* that *Kirwan*, *Bergmann*, and other *mineralogiſts*, aſſert, that the ſilver is mineralized in the cor-

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[*] *Juſti, Chemiſche Schriften.* I. Th.

[†] *Abhandl. vom.* Hornerz, von *Lommer*. Leipzig, 1776.

[‡] *Experiments* on the mixture of ſome minerals.

neous-ore by the ſulphuric as well as by the muriatic acid.

3. *Sage**, of *Paris*, has examined the corneous ſilver-ore from Peru; and ſtates the *maximum* contained of ſilver, in the *hundred*, to be from 70 to 74. He adds, that the metal is mineralized by muriatic acid; and, beſides, combined with a peculiar fattiſh matter.

4) *Laxmann*†, of *Peterſburg*, on the contrary, maintains, that no muriatic acid is contained either in the Siberian or Saxon corneous ſilver-ore; and that in it the metal is mineralized by ſulphur, in the ſame manner as in the glaſerz, viz. the vitreous or ſulphurated ſilver-ore.

On conſidering this diſcordance among the learned, reſpecting the nature of the ſubſtance which mineralizes the ſilver in the corneous-ore, I think that it will not be ſuperfluous if, to the enquiries of theſe chemiſts, I add the experiments which I had the opportunity of making with ſeveral varieties of this ſilver-ore.

A.

The above-mentioned *maſſive corneous ſilver-ore*, from the larger ſpecimen in the Electoral collection at Dreſden, was the principal ſubject of my analyſis, a ſufficient quantity of it having been given me for that purpoſe with the greateſt liberality.

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* Analyſe Chim. et. concord. des trois regnes. Paris, 1786.

† Nov. Comment. Acad. Scient. Petrop. 1774.

) If the artificial horn-ſilver (muriat of ſilver), be melted by itſelf on the ſpoon before the blow-pipe, it ſoon and readily fuſes into a globule; and, when combined with mineral alkali, the ſilver is immediately reduced. But the native corneous ſilver-ore does not melt ſo eaſily; it rather runs into the conſiſtence of pap, and at the ſame time ſeparate metallic grains tranſude. Its reduction, by means of ſoda, is ſomewhat more difficult than that of the artificial horn-ſilver, and the reaſon of this difference depends on the portion of iron contained in this ore.

b) Upon *two hundred* grains of the corneous ſilver-ore I poured three times their weight of pure nitric acid; but no action took place, either in the cold or in the heat of boiling; only a ſubtle brown-red iron-ochre was ſeparated, which, being waſhed off from the remaining ore, and dried, amounted to 4 grains. Cauſtic ammoniac, added to the nitric acid employed, precipitated 5 grains more of iron. When it was afterwards mixed with muriatic acid, only a pale milky colour was produced, but no real corneous ſilver-ore depoſited. It followed from this, that neither any free native ſilver, nor any portion of it mineralized by ſulphur, had been contained in that ore. The horn-ſilver, after treatment with nitric acid, was reduced by twice its weight of ſalt of tartar, and yielded 133 grains of reguline ſilver.

c) 1ſt. For the purpoſe of finding out, more accurately, its conſtituent parts, I mixed 200 grains with 600 grains of the pureſt alkali prepared from tartar, and brought the mixture into the ſtate of fuſion in a glaſs retort, applying the neceſſary degree of heat. After refrigeration, I broke off the upper half of the retort, ſoftened the fuſed maſs, which was of a light-brown colour, with hot diſtilled water, filtered the whole, and edulcorated the reſidue.

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2dly. This reſidue was then diſſolved in nitric acid. The ſolution acquired a brown tinge, and the ſcum floating upon the liquor aſſumed the colour of bricks. When the argenteous parts were completely diſſolved, there remained 8½ grains of a brown-red powder, which imparted a golden yellow colour to the aqua regia, with which it was digeſted, and left a white reſidue behind. This laſt conſiſted of horn-ſilver, mingled with a ſlight portion of the *gangue*, or *matrix* of the ore, and afforded, on reduction, 2 grains more of *ſilver*. Cauſtic ammoniac precipitated from the yellow ſolution 7 grains of *oxyded iron*.

3dly. The nitric ſolution of the ſilver was precipitated by common ſalt; and the muriat of ſilver thus obtained weighed, after reduction by means of ſoda, 134½ grains of reguline ſilver.

4thly. The fluid, left after the ſeparation of the horn-ſilver, had a pale-yellow colour, owing to a *portion of iron*; which, precipitated by pure ammoniac, weighed 5 grains.

5thly After this, I proceeded to examine the ſaline maſs, diſſolved in diſtilled water, and ſeparated from the ſilver, after the corneous-ore had been fuſed with pure alkali (*i*). On ſaturating this maſs with diſtilled vinegar, the ſolution was rendered turbid, and a looſe white earth depoſited, which, collected and dried, amounted to 3¼ grains of *argillacious earth*.

6thly. The argil being ſeparated, the ſolution was reduced to a dry ſalt by evaporation, and the alkohol, affuſed upon it, took up the acetite of pot-aſh. The neutral ſalt, which was left behind by this proceſs, and which conſiſted of the mineralizing muriatic acid and the alkali employed, I diſſolved in water, and obtained from it, by repeated evaporation and cryſtallization, 117½ grains of *muriat of pot-aſh*.

7thly. In order to learn whether and in what proportion *ſulphuric acid*, which by ſome writers has been mentioned as one of the conſtituent parts of the corneous ſilver-ore, were really preſent in it, I again diſſolved that ſalt in diſtilled water, and dropped into it liquid muriat of barytes. The mixture became turbid, exhibiting that appearance which indicates the preſence of only a ſlight quantity of ſulphuric acid. I continued to add the barytes, until no more turbidneſs appeared. The weight of the precipitate thus obtained was 3 grains: but, as in theſe three grains of ſulphated barytes the acid cannot properly be eſtimated to be more than half a grain, I think this quantity is too trifling to be conſidered as one of the eſſential conſtituent parts of the corneous ſilver-ore. But if that half grain of ſulphuric acid be eſtimated equal to 1½ grain of ſulphat of pot-aſh, and be ſubtracted from the above 117½ grain of digeſtive ſalt, or muriat of pot-aſh, there will remain of the latter only 116 grains, in which the concentrated muriatic acid amounts to 42 grains. Therefore,

One *hundred* parts of this corneous-ore contain

Silver	67,75
Muriatic acid . . .	21
Oxyd of iron . . .	6
Argil	1,75
Sulphuric acid . . .	0,25
	96,75

B.

I likewiſe examined the *corneous ſilver-ore* found in the *Schlangenberge*. *One hundred* grains of it, mixed with 300 of ſoda, were fuſed in a ſmall retort; and, after the ſaline contents of this maſs had been diſſolved in hot water, the remaining ſilver was diſſolved in nitric acid. I then fully ſaturated with muriatic acid the aqueous alkaline ſolution, which contained the common or culinary ſalt, formed by the muriatic acid of that ore, and put it to the teſt with muriat of barytes. The portion of ſulphat of barytes, thus generated, was as inſignificant as that from the Saxon corneous-ore; ſo that alſo, in this caſe, the ſulphuric acid may be conſidered only as an accidental conſtituent part.

To the nitric ſolution of the ſilver I added common ſalt; and thus I produced again the muriat of ſilver, which weighed 91½ grains, and afforded 68 grains of *ſilver*, reduced to the reguline ſtate. What was wanting to make up the firſt hundred grains of the corneous-ore, conſiſted of ferruginous ochre and quarzoſe matrix.

Hence it is obvious, that the *Siberian* corneous ſilver-ore here examined, almoſt perfectly agrees with the preceding *Saxon* one in its exterior characters, as well as in the conſtituent parts.

C.

The experiments made with the argillo-muriated ſilver-ore *(butter-milch ſilver)*, deſcribed before (page 113), are the following:

a) Ignited by itſelf upon charcoal before the blow-pipe, it feebly conglutinated together, at the ſame time that mi-

nute

nute globules of metallic ſilver were oozing through the maſs. When fuſed with glaſs of borax, it diſſolved into a clear, light-green, vitreous globule, and yielded a button of pure fine ſilver.

b) Upon 35 grains of that ore I poured nitric acid, and made it boil. Neither effervefcence nor red vapours appeared; as, upon the whole, the acid ſeemed to attack it but weakly. The reſiduum aſſumed the form of a precipitate, reſembling a cheeſy coagulum. When the acid, then tinged of a faint blue, was ſeparated through a filter, it admitted of combination with common ſalt, without being rendered turbid, or yielding any precipitate. By the addition of corbonat of ammoniac to exceſs, argillaceous earth was thrown down, and the liquor appeared of a rather deep blue. But, after it had been ſuper-ſaturated with ſulphuric acid, and iron immerſed into it, it depoſited a thin coppery cruſt.

The dried reſidue weighed 30 grains. It was extracted by repeatedly pouring upon it cauſtic, or pure ammoniac, agitating it frequently. Nitric acid being added to a few drops of it, ſome horn-ſilver immediately precipitated. The whole of this ſolution, when evaporated by a gentle heat, dried up to cryſtalline flexible membranes of a pearl-grey, which tarniſhed into blue by expoſure to air; and, when gently melted in a ſmall ſilver-cup, ran into a waxy ſubſtance. The weight of this fuſed muriat of ſilver amounted to 10½ grains.

When the argil, that was left behind after the extraction of the horn-ſilver by ammoniac, was melted with ſoda, it ſtill afforded a bead of ſilver of ¾ of a grain. As this is equal to one grain of muriat of ſilver, the above 36 grains of this foſſil ſoſſil contained 11½ grains of muriated, or 8⅝ of metallic ſilver, and 2⅞ grains of concentrated muriatic acid.

Hence *one hundred* parts of the argillo-muriated ſilver ore contain,

Silver	24,64
Muriatic acid	8,28
Argil, with a ſlight trace of *copper* .	67,08
	100

It is owing to the argil contained in this ore that it does not aſſume the ſame appearance when heated on charcoal as the common horn-ſilver, but that the metal tranſudes in the reguline ſtate in ſmall globules; for as that earth deprives the muriated ſilver of its acid when heated, the ſilver is enabled to aſſume the metallic ſtate. And it is on this account that the ſame phenomenon took place when I mingled artificial horn-ſilver with argillaceous earth, and ſubjected it to ignition upon a piece of charcoal, with the aſſiſtance of the blow-pipe.

D.

With the view of inveſtigating the nature of the *ſilver-ore*, called *alkaline* by *Juſti*, I diſſolved *one ounce* of it in pure nitric acid, and mixed the filtered ſolution with muriatic acid. It, indeed, turned ſomewhat opaline; but no muriat of ſilver was ſeparated by this proceſs, nor was there any reguline ſilver precipitated upon immerſing into it a ſmall lamina of copper. Finding, therefore, that the portion of ſilver contained in the lime-ſtone could not be diſcovered in the nitric ſolution, I ſearched for it in the brown muddy reſidue of the filtered ſolution. This emitted an empyreumatic ſmell on being gently ignited, weighed afterwards 2 grains, and yielded with pure alkali a bead of fine ſilver. Hence it is probable, that in this foſſil the ſilver is combined with muriatic acid; and, reckoning upon this reſult, the quantity of muriated ſilver which it ſeems to contain, may be eſtimated at from *one and a half* to *two* ounces in hundred pounds. *Juſti* boaſted of a method of extracting the ſilver from that mineral, known to himſelf alone; as, when treated by any of the uſual proceſſes, this metal could never be procured from it.

As ſilver, notwithſtanding its great affinity with muriatic acid, enters into no combination with it while in the perfect reguline ſtate; and ſince that metal, as far as we know, is never found in the bowels of the earth in an oxyded ſtate, it is difficult to aſcertain the operation of nature in producing the corneous-ore. *Bergmann*[*] was of opinion, that *Woulfe* had ſolved that doubt by aſſerting, that in the above-mentioned ore he had traced the ſulphuric acid, beſides the muriatic: for ſilver unites readily with ſulphur; and, ſince ſulphurated ſilver not unfrequently undergoes a decompoſition, more eſpecially when, as in this caſe may be conjectured from the preſence of ferruginous ochre, ſome pyrites diſpoſed to diſintegration intervenes, the ſulphur paſſes over into the ſtate of a free acid, and forms ſulphat of ſilver. If now muriatic acid interferes, it will, by virtue of its greater affinity to ſilver, decompoſe the ſulphat, and inſtead of it form corneous-ore.

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[*] *Torb. Bergmann* on the generation of natural corneous, or muriated metals. *Crell's Chemiſche Annalen*, 1784. Number 4, page 377.

Of that corneous ſilver-ore which is found in regular cubic cryſtals, *Bergmann* had already conjectured that it might be conſidered as pure, and free from all ſulphuric acid. He alſo wiſhed to convert this conjecture of his into an eſtabliſhed truth, by duly examining that foſſil; *for*, as he very juſtly ſays, *it is better to ſacrifice ſuch a ſpecimen, ſcarce as it yet is, to inveſtigation, rather than to deprive the ſciences of a means of enlarging our knowledge by preſerving it.*

The wiſh of the immortal *Bergmann* is in ſome degree accompliſhed, and his conjecture, for the moſt part, confirmed by the preſent enquiry; with the unimportant difference, however, that, inſtead of cryſtallized corneous-ore, I have employed a ſpecimen of that which occurs in lumps, or *maſſive.*

In order to comprehend how nature can generate the corneous ſilver-ore, without the interpoſition of ſulphur or ſulphuric acid, we may receive ſome light from the following intelligence, taken from a letter of *Prouſt*, in *Rozier's Journal de Phyſique.* It is there ſtated, that the coined ſilver of the Spaniſh ſhip San Pedro d'Alcantara, that was wrecked on the coaſt of Portugal, became coated with a blackiſh cruſt of $\frac{1}{48}$ of an inch thickneſs, during the ſhort time before it was recovered from the ſea. This cruſt broke off in ſcales, and was a true muriat of ſilver. Moreover, *Pallas*[*] relates, that he has found on the Jaik, in Siberia, ſeveral old Tartarian ſilver coins, which in that tract of ſaline land were converted into true muriat of ſilver, ſome throughout their whole maſs, and others on the ſurface only.

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[*] *Nordiſche Beytraege,* III. Vol.

From this knowledge of the conſtituent parts of the corneous-ore, art is enabled to imitate nature pretty nearly. If muriat of ſilver be made to fuſe uniformly at a moderate heat, an artificial corneous-ore is produced, which may be made more ſimilar to the natural one by adding, before the fuſion, a proportional quantity of iron-ochre. And if muriated ſilver be diſſolved in cauſtic ammoniac, and the fluid evaporated in a gentle warmth, the horn-ſilver remains in ſmall glittering ſcales, reſembling thoſe with which the native corneous-ore is found in part covered. But, if this ſolution be left to ſpontaneous exhalation in the air, the horn-ſilver will ſometimes ſhoot into ſolid regular cryſtals, of the ſame appearance with the cubic cryſtals of the corneous-ore.

SECOND SECTION.

Red Silver-ore (Rothgültigerz).

The principal character by which this beautiful genus of ſilver-ores is externally diſtinguiſhed from others, conſiſts in a peculiar red colour, on account of which it is ſubdivided into two ſpecies, the *light*, and the *deep-red* ſilver-ore. The colour of the firſt varies from a bright ruby to a garnet red; that of the ſecond inclines more or leſs to a ſteel-grey, but the characteriſtic crimſon tint is ſoon made to appear by ſcraping or rubbing the ore. The deep-red ſilver-ore is uſually opake; the light-red, on the contrary, is in various degrees tranſparent.

With reſpect to external form, the red ſilver-ore is found *maſſive*, *diſſeminated*, *inveſting* or ſuperficial, *dendritic*, and at times regularly cryſtallized. Its cryſtals uſually poſſeſs the form of hexahedral columns, without any pointed

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termination, or ending in trihedral or hexahedral pyramids. The light-red ore alſo occurs in ſix-ſided pyramids.

The denomination of *Rothgültig*, or *Rotht gültiges Erz*, given by the older German miners to this genus of ſilver-ores, was intended to ſignify that it contained a portion of that noble metal, and thus to diſtinguiſh it from other ores, which reſemble it in form and colour; but, with reſpect to their argenteous contents, are *deaf* (*ungültig*), or of no value; inſtances of which are afforded by the native red ſulphuret of arſenic, red-blende, and garnet. In proceſs of time, this appellation has degenerated into *Rothgülden*, by which the unexperienced might be miſled to ſuſpect in this ore ſome portion of gold.

Concerning its conſtituent parts, it is the common opinion and doctrine, that the ſilver is mineralized in it by *arſenic*, as well as by ſulphur. Theſe three, *ſilver*, *ſulphur*, and *arſenic*, are in all elementary books of mineralogy, and by all authors, ſtated as the conſtituent parts of this ore, to which ſome add only a portion of iron. Among thoſe writers which, in *chemical mineralogy*, are reckoned claſſical, *Henckel* ſeems to be the firſt who mentions arſenic as one of the chief conſtituent parts of the red ſilver-ore, when he ſays, "*The high-red ore, beſides ſilver, conſiſts merely of arſenic; the deep-red contains ſulphur alſo.*" After him, *Wallerius* introduces it by the name "*Argentum arſenico et ſulphure mineraliſatum.*" *Cronſtedt* adopts this ſtatement, adding only ſome ferruginous ingredient. *Bergmann*, likewiſe, is of the ſame opinion, in his *Sciagraphia*[*], calling it "*Argentum cum arſenico ſulphure* mi-

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[*] Torb. *Bergmann*, Sciagraphia regni mineralis. Lips. et Dreſd. 1782, page 108.

mineraliſatum:" and, in his diſſertation de *Arſenico**, he ſays, "*Arſenicum cum argento ſulphurato mineram argenti rubram conficit:*"—and at the ſame time he ſtates their proportion to be, of *ſilver* 60, of *arſenic* 25, and of *ſulphur* 13†. It was on the authority of theſe eminently learned men that all the other writers have received the above-mentioned component principles of this ore as unqueſtionable facts, and have transferred them into their works.

Yet, upon the whole, arſenic is not ſo general a mineralizer as has been hitherto ſuppoſed. Hence all the hypotheſes grounded on its pretended preſence, and according to which arſenic was conſidered as a principle neceſſary to the generation or maturation of metals, eſpecially ſilver, can no longer ſubſiſt. This ſuppoſition, which has never before been queſtioned, that moſt genera of ſilver-ores contain arſenic, has occaſioned the *prize queſtion* of the *Royal Academy of Sciences at Berlin*, 1773, "*To what purpoſes does* "*Nature employ the arſenic contained in metallic ores?* "*Can it be proved, by experience, that it effectually ſerves* "*to bring the metals to maturity? And if ſo, in what man*"*ner, and how far is this effected?*"—However truly Mr. *Monnet*, whoſe paper has been honoured with the prize, has demonſtrated that arſenic has no eſſential ſhare in the generation of metals, he might as well have deduced his demonſtration in the ſhorteſt and moſt ſolid way, *a priori* from the non-exiſtence of arſenic in the red and white ſilver-ores, and in the grey copper-ore *(Fahlerz)* abounding in ſilver—(for theſe the above Academy ſeems principally to have had in view on making their queſtion)—had he convinced himſelf of the falſehood of the premiſes by a previous enquiry duly inſtituted.

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* Ejus'd. Opuſcul. Phys. et Chem. Vol. II. page 298.

† *Loc. cit.* page 303.

It is probable the red-arſenic, which externally reſembles the deep-red ſilver-ore, and, according to *Henckel's* teſtimony, uſed to be called *unripe red ſilver-ore*, has firſt ſuggeſted the idea of the preſence of arſenic in thoſe ores of ſilver.

After this digreſſion, I now proceed to the chemical analyſis itſelf. This, however, was particularly performed with the light-red ſilver-ore, of which I had an opportunity of ſelecting, for my repeated experiments, a ſufficient number of fragments, pure and free from extraneous matter, from the mines of the *Upper-harz*, and thoſe of *Saxony*.

A.

a) Upon *five hundred* grains of bright, cryſtalline, red ſilver-ore, from the pit *Catharina Neufang*, at *Andreaſberg*, moſt finely pulverized, I poured ſix times their quantity of a mixture of equal parts of nitric acid of 1,350 ſpecif. grav. and diſtilled water. The phial was kept for ſeveral hours in a low digeſting heat, ſo that the agency of the acid could be but moderate. I then diluted the ſolution with water; cauſed it to boil; and, after the reſiduum had ſubſided to the bottom, I decanted the clear ſolution. Upon the remaining pulverulent ore, a quantity of nitric acid and water, equal to the preceding, was again affuſed; and, in the ſame manner, proceeded with as at firſt. The ore appeared now to have been effectually decompoſed; and for this reaſon the ſolutions, together with the reſiduum, were put on the filter, and the latter properly waſhed.

b) The filtered nitric ſolution had no colour at all, having been very much diluted by the water by which the reſidue had been edulcorated. I ſubjected it to evaporation to one eighth part, and found the bottom of the evaporating glaſs-veſſel, after cooling, covered with copious, finely-grained, reſplendent, and heavy cryſtals of a grey-white. To aſcertain their nature, I procured, by a ſeparate proceſs, a quantity of a ſolution of the ſame red ſilver-ore, ſufficient for this enquiry, and found that they were *ſulphat of ſilver.* Being aſſured of this, I diſſolved that ſulphat by a proportionate quantity of water, aſſiſted by heat, added it again to the nitric ſolution, and combined this laſt with muriatic acid, as long as any muriat of ſilver would precipitate; which, when collected, edulcorated, and dried, was found to weigh 391½ grains.

c) The fluid, from which the horn-ſilver had been thus ſeparated, was then reduced to a ſmaller bulk, by diſtillation from a retort. This concentrated fluid became turbid, and left another grain of muriated ſilver on the filter. At this ime it contained no other foreign ſubſtance, except a conſiderable portion of ſulphuric acid.

d) What remained undiſſolved by the nitric acid, conſiſted of an aſh-grey, pretty looſe, or flocculent powder, of 202 grains in weight. When this had been gently digeſted for half an hour, with a mixture of 5 parts of muriatic acid, mixed with 1 part of the nitric, and then diluted with half its quantity of water, there remained, after filtering, careful edulcoration, and drying, 65 grains; which were the ſulphureous contents of the ore. When this reſidue had been gently heated, the ſulphur deflagrated, leaving 6½ grains of muriated ſilver behind. This *ſulphur*, therefore, conſiſted of 58½ grains.

e) After the filtered ſolution had been evaporated in part, it was poured into a large quantity of water. By this ma-

management, a white precipitate immediately enſued, which being ſeparated by the filter, edulcorated, and dried, and laſtly heated in a porcelain cup, gave 133 grains in weight. But I could not find the leaſt trace of arſenic in it, though I had ſubjected it to all the trials deemed proper for diſcovering its preſence. On the contrary, it was manifeſt, that this precipitate wholly conſiſted of *oxyd of antimony*, quite of the ſame nature with that which is produced when muriatic ſolutions of antimony are precipitated by water. On expoſing it to heat, a ſmall portion of moiſture ſtill evaporated, attended with a muriatic ſmell, which was hardly perceptible. When again put on a teſt, and mingled with a third part of charcoal duſt, the coaly powder was ſlowly conſumed, by burning, without any arſenical ſmell, and left behind it the metallic oxyd, poſſeſſed of a grey colour, and partly blended, partly covered with a quantity of fine, grey-white, ſhining, acicular cryſtals, or the flowers of antimony, as they are called. But when it was fuſed in a covered crucible with tartar and powdered charcoal, it was completely revived into *reguline antimony*, which being blown off with the bellows, a *bead of ſilver* was left, weighing half a grain.

f) The liquor alſo, from which the antimonial oxyd was ſeparated, contained free ſulphuric acid. On this account I put it into a retort, together with the nitric acid, from which the ſilver had been precipitated in the ſtate of horn-ſilver, by means of muriatic acid, and continued the diſtillation until, at this temperature, nothing more would paſs over; but, on raiſing the heat, thick white vapours had begun to riſe. The fluid left behind in the retort was found, upon trial, to be concentrated *ſulphuric acid.* Upon diluting this laſt with water, and ſubſequent affuſion of muriated barytes, the ſulphat of barytes from thence produced, amounted, after edulcoration and deſiccation, to 194 grains.

Conſequently, the conſtituent parts diſcovered by theſe reſearches, are, *ſilver*, *antimony*, *ſulphur*, *and ſulphuric acid*. It remained yet to inveſtigate, what are the proportions and the manner of combination of theſe principles, which conſtitute the red ſilver-ore.

Firſt, concerning the quantity of ſilver contained in this ore here examined, the muriat of ſilver (*b*) together with thoſe portions that were left behind on the deflagration of the ſulphur (*d*), and the concentration of the fluid from which the former had been ſeparated (*e*), amounted, in the whole, to 399 grains. Theſe being reduced, (including the one half grain obtained on driving off the antimony), yielded 300 grains of pure ſilver. This ſtatement alſo perfectly agreed with the reſult of another experiment, which, by way of collateral proof, I performed in the dry way: for having, with this view, divided one *docimaſtic centner* of that ore into two parts, and carefully refined each of them on the cupel, incloſed in four times their weight of hammered lead, I recovered in each cupel a bead of fine ſilver of 30 pounds weight.

I endeavoured to aſcertain, by the following counter-experiments, the metallic portion of the *oxyd of antimony*; which, after deducting, by gueſs, one grain for the half grain of ſilver which was contained in the ore, amounted to 132 grains. Upon *one hundred* grains of pure reguline antimony I poured four parts of muriatic acid; and, when warmed, I continued dropping nitric acid into this fluid, until all the metal was diſſolved. After the ſolution had been concentrated by gentle evaporation, I added water to precipitate the diſſolved metal. The precipitate thus obtained, after lixiviating the ſaline parts, and deſiccation, weighed 130 grains. Hence the above 132 grains are equal to 101½ grains of metallic antimony.

With regard to the *ſulphuric acid*, it may be doubted, whether the acid here diſcovered, had really previouſly exiſted as ſuch in the red ſilver-ore, forming, with the metal, ſulphat of ſilver; or whether that acid ought not rather to be conſidered as a product, ariſing from the oxygenation of the ſulphur, while the ore was diſſolving in nitric acid. But even the external properties of that ore, eſpecially its tranſparence, and the abſence of metallic luſtre, will ſufficiently prove, that the latter is not the caſe: for, with regard to the mineralization, ores may be conveniently divided into two claſſes. The *firſt* comprehends the true ores in the ſtrict ſenſe; that is, thoſe only in which the metallic portion is either in the perfect, or very nearly perfect, reguline ſtate, and whoſe mineralizer is ſulphur. A metallic luſtre, and abſolute opacity, are eſſential properties of ſulphurated ores of this kind. To the *ſecond* claſs belong thoſe ores, the metallic part of which is acidified by oxygen, either alone, or in combination with ſulphur and acids. The exterior characters of the ores of this claſs are various. Some of them are *tranſparent* even to *pellucidity*; others, on the contrary, exhibit only an earthy appearance. But all theſe are particularly diſtinguiſhed from the genuine or true ores, by the total abſence of metallic ſplendour. Among the ſilver-ores, therefore, the *vitreous ſilver-ore (glaſerz)*, the *black ſilver-ore (ſprödglas-erz)*, and the *white ſilver-ore*, belong to the firſt claſs, or ſulphurated ores; but the *red*, and the *corneous ſilver-ore*, belong to the ſecond claſs, or ores mineralized by acid principles.

The peculiar manner in which the nitric acid exerts its diſſolving power on the red ſilver-ore during the digeſtion, affords another argument to ſhew, that in this ore the portion of ſilver does not exiſt in its perfect metallic ſtate, and mineralized by ſulphur; but, on the contrary, is combined with oxygen, at leaſt for the greater part; and hence, that it there exiſts in a calciform ſtate. The nitric acid acts upon it much too weakly, to oxygenate the ſulphur in any conſiderable degree; in conſequence of which, only a proportionally ſmall quantity of nitrous gas is produced in this ſolution. This fact is ſtill more confirmed by the following experiment. Some finely pulverized red ſilver-ore, together with a large quantity of ſtrong muriatic acid, were ſubjected to digeſtion for ſome hours, at a boiling heat. The acid, ſeparated by filtration, was examined after cooling, and was found to contain, not only ſilver, and antimonial particles, but alſo ſulphuric acid. Now, as muriatic acid alone is incapable of converting ſulphur into a free or uncombined acid, it follows, that the ſulphuric acid muſt already before have exiſted in that ore, in the capacity of an acid. Even *Henckel*, whoſe great merits in chemical mineralogy are at preſent almoſt totally diſregarded, has already ſtated it as a certain fact, that the ſilver may be extracted from its red-ore, by muriatic acid alone, aſſiſted by ſucceſſive digeſtions at the degree of boiling. It is alſo probable, that the ſulphuric acid, preſent in that ore, contributes to the ſolubility of the metal in the muriatic acid.

The ſulphuric acid, contained in the above 500 grains of the red ſilver-ore, produced 194 grains of ſulphated barytes. Other comparative experiments proved to me that this acid amounted to 85½ grains of 1,850 ſpecific gravity. But as this acid muſt be ſuppoſed to be combined in this ore with the ſilver in a concrete ſtate, or *freed from* water, and not in the ſtate of liquid ſulphuric acid, I hope to come pretty near the mark, if, till a more accurate computation can be made, I allow 40 grains for the ſulphuric acid of that degree of concentration.

In order to aſcertain whether any volatile parts, and of what kind, were diſcharged by the red ſilver-ore, when treated in fire with excluſion of air, *one ounce* of it, coarſely triturated, was placed in a ſmall glaſs-retort, which, being connected with the pneumatic quickſilver-apparatus, I continued to heat till the ore was in fuſion. However, nothing paſſed over into the jar filled with mercury, excepting that portion of atmoſpheric air, which was expelled from the retort by the heat. In the intermediate glaſs-balloon *volatile ſulphureous acid* collected, in the form of fine drops of dew; in the neck of the retort there appeared a ſlight trace of ſublimed yellow ſulphur; but the ore in the retort did not loſe ſo much as one entire grain of its weight.

Theſe ſame experiments, made for the purpoſe of diſcovering the ingredients in the red ſilver-ore, I repeated with another ſpecimen from the ſame mine; but, as the reſult of theſe laſt, excepting ſome unimportant deviations, agreed with the former, I am ſatisfied with the conſtituent parts reſulting from the inveſtigation of the above-mentioned 500 grains, and which are:

Silver	300
Reguline antimony	101,5
Sulphur	58,5
Concrete *ſulphuric acid*	40
	500 grs.

Therefore, *one hundred* parts of this *red ſilver-ore*, from *Andreasberg*, contain:

Silver	60
Reguline antimony	20,3
Sulphur	11,7
Concrete *ſulphuric acid*	8
	100.

B.

The ſecond ſpecies of the red ſilver-ore, which I have analyſed, is the *bright-red and cryſtalline*, from *Churprinz Friedrich Auguſt*, near *Freiberg*. But, as I treated theſe in the ſame manner as the preceding, I ſhall confine myſelf to the reſults only; according to which, *one hundred* parts of this ore contain:

Silver	62
Reguline antimony	18,5
Sulphur	11
Concrete *ſulphuric acid*	8,5
	100.

This *Saxon* foſſil, therefore, perfectly agrees with that from the *Harz*, with regard to its conſtituent parts, and likewiſe very nearly as to their proportions. The quantity of ſilver alſo was found to be the ſame, when the proceſs was performed in the dry way; ſince 100 pounds of this ore, properly dreſſed or mingled with four times its weight of lead, and ſubjected to cupellation, likewiſe afforded 62 pounds of metallic ſilver.

In this *Saxon* red ſilver-ore, as in the foregoing, there was no veſtige of arſenical matter to be found, although arſenic conſtantly accompanies the ores dug out from that mine.

In the preceding analytical reſearches, concerning the red ſilver-ore, I have indeed mentioned *ſulphur*, and *ſulphuric acid*, as two particular products; yet I do not mean to ſay by this, that they are two ſeparate and really diſtinct conſtituent parts, actually exiſting in the ore. It is rather more probable, from the nature of the ſubject, to ſuppoſe, that in the undecompounded ore, both together conſtitute only one homogeneous ingredient part, and that the oxygen, by which the ſulphuric acid was generated in this proceſs, had before been uniformly diffuſed over the whole maſs of the ſulphur. But, if ſo, there is no doubt, but that the red colour of the ore, which in general is erroneouſly aſcribed to ſome arſenical matter, depends on that ſtate of ſulphur in its firſt degree of oxygenation, which by ſome is rightly called *oxyd of ſulphur*. On this account, the *ſilver*, *antimony*, *ſulphur*, and *oxygen*, are, in the ſtrict ſenſe, the genuine conſtituent parts of the red ſilver ore, taken in its natural ſtate.

Laſtly, I did not think it neceſſary to re-examine what *Bergmann* aſſerted, in his Eſſay de *Arſenico*, concerning the red ſilver-ore. He ſays—“ *Minera argenti rubra egregie* “ *aquâ forti decomponitur, argentum et arſenicum ſuſcipiente,* “ *adeo, ut tandem ſolum ſulphur in fundo reſtet.*” From this it might be inferred, that *Bergmann* had employed for this experiment a ſpecimen of the red ſilver-ore, which had no antimony, but really ſome arſenic, among its conſtituent parts; otherwiſe, by the eſtabliſhed principles of chemiſtry, the antimoniacal part of the ore muſt of courſe, together with the ſulphur, have remained behind as a metallic oxyd, inſoluble in nitric acid. In order to ſet this contradictory point in a proper light, I boiled five parts of ſtrong nitric acid upon 100 grains of this red ore for ſome time; after which the mixture was diluted with water, and the ſolution filtered while yet warm. This extraction by ſtrong nitric acid was ſucceſſively repeated, until only a ſmall portion of ſulphur remained. The ſolution procured by the firſt digeſtion, depoſited, in the cold, granular ſulphat of ſilver; but thoſe of the ſucceeding digeſtions yielded alſo ſome particles of antimony, which ſubſided in delicate, light ſcales, of a ſilvery luſtre. By this experience, therefore, I learn, that reguline antimony, inſtead of being corroded by nitric acid into an indiſſoluble oxyd, makes an exception from that rule when in combination with ſulphuric acid, as was here the caſe. And, for this reaſon, I found that a ſolution of this metal was effected, when, by way of a comparative trial with pure reguline antimony, I uſed a menſtruum compoſed of ſtrong ſulphuric and nitric acids. This fact has already been mentioned by *Wenzel*[*]. Upon this property of antimony, that its ſolubility in nitric acid is promoted by the ſulphuric, is founded the rule that ought to be obſerved in performing proceſſes on the red ſilver-ore; which is, that for the purpoſe of extracting its ſilver, weak nitric acid, and only a gentle digeſtion, ſhould be employed.

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[*] See his *Lehre von der Verwandtſchaft der Koerper*. Dresden, 1777. page 182.

THIRD SECTION.

Vitreous Silver-ore. (Silberglanzerz.)

THE appellation *glaſerz*, which the German miners have given to this richeſt ſort of all ſilver-ores, is inconſiſtent with its real natural qualities, and can only have been retained from the antiquity of the term. Not only is the abſolute opacity of this ore, but alſo its ſoftneſs, and ductility, (on account of which it may be cut, hammered, and coined, as eaſily as lead) are abſolutely incompatible with the notion of *glaſs*. An inſtance of the laſt mentioned property is afforded by thoſe medals, which were made of it under the reign King *Auguſtus* I. (of Poland,) and had the impreſſion of his portrait. *Henkel*[*] was therefore fully entitled to ſay—" Glaſerz *is meant to ſignify the ſame as* " glanzerz, *which name it probably has received at thoſe* " *mines, where no other ore, conſtantly poſſeſſing luſtre, was* " *to be found; and, in particular, it ſeems, that the miner* " *who gave it firſt that name, happened to meet with a ſpecies of glaſerz of variegated colours.*" Supported by this authority, and ſtill more ſo by the nature of that ore, I ſhall make uſe of the more ſuitable denomination, *ſilberglanzerz*.

That this ſpecies of ore is a mere *ſulphuret of ſilver*, is too well known to need farther confirmation. Only the proportion of its conſtituent parts, as ſtated by mineralogical writers, appeared to me to require correction. This, upon *Bergmann*'s[†] authority, is generally ſaid to be 75 parts of *ſilver*, and 25 of *ſulphur.* The portion of the ſilver is rated much higher by *Brünnich*[*]: namely, at 180 marks, or at *ninety* in the *hundred.* On the contrary, *Sage*[†] eſtimates the ſulphur at 16 parts in the hundred of this ore, and conſequently the ſilver at 84. By the following experiments it will be ſeen, that of theſe two, the opinion of *Le Sage* is the neareſt to truth. That this more accurate ſtatement was before known among the earlier authors in mineralogy is proved by theſe words of *Lazarus Erker*[‡] "*Thus* "*we may reckon among the ſilver ores of eaſy fuſion, the* "*moſt eminent of theſe, the glaſerz, which is compact, of a* "*lead colour, in quality nearly equal to native ſilver, and* "*loſes in the fire little more than one ſixth part, all the* "*reſt being good pure ſilver, &c.*"

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[*] *Henkel redivivus.* page 51.

[†] *Sciagr. reg. min.* § 163.

A.

a) *One hundred grains* of cubically cryſtallized vitreous ſilver-ore (from the mine *Himmelsfürst*, near *Freiberg)*, previouſly cut into ſhreds, were digeſted, in a low heat, in eight times their weight of nitric acid, of 1,350 ſpecif. grav. diluted with half its quantity of water. The activity of the acid proved to be but moderate, partly becauſe, as the ore was not capable of being pulverized, on account of its ſoftneſs and ductility, the ſhreds preſented a conſiderably ſmaller ſurface to the acid. After the ſolution had been accompliſhed, the remaining browniſh-yellow ſulphur, when ſeparated, waſhed, and dried, weighed 13 grains; but, on being burnt on a porcelain teſt, it left one grain and a half of ſulphated ſilver, which, fuſed with mineral alkali, gave a ſilver-button of one grain.

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[*] *Cronſtedt's* Mineralogie, verm. d. *Brünich.* 1780. page 186.

[†] Analyſe. Chim. et concord. de trois regnes. par M. *Sage.* Paris, 1776. Tom. III. page 250.

[‡] *Erker* Probierkunſt. Francfort, 1598. page 9.

b) The colourleſs nitrous ſolution, when combined with common ſalt, edulcorated, and highly deſiccated in a warm temperature, yielded 122 grains of horn-ſilver, the metallic portion of which amounted to 84 grains. By this, including the above-mentioned *one* grain, the proportion of the ſilver contained in 100 parts of that ore is determined at 85.

c) The fluid decanted from the muriat of ſilver, contained nothing but a ſmall proportion of diſengaged ſulphuric acid. This, however, ſhould not in this inſtance be conſidered as a conſtituent part of the ore, but was undoubtedly formed during its long digeſtion in nitric acid. Hence thoſe 15 grains, which, after deducting the 85 of ſilver, remain to make up the 100 of the ore employed, may all be ſafely put into our account, as its ſulphureous part.

B.

Next, in order to examine the truth of the preceding reſult, in the dry way, I took the vitreous ſilver-ore from *Joachimsthal*, in Bohemia. An hundred grains of it were divided into two parts, and each of them placed in a ſeparate aſſaying teſt, well dried beforehand under the muffle. Heat was then applied, at firſt moderate, to drive the ſulphur ſlowly off, and only towards the end its intenſity was increaſed to the requiſite degree. The beads of ſilver obtained from each teſt, were of equal weight, and their ſum amounted to $84\frac{11}{16}$ grains.

In conſequence of the approximation of this laſt reſult to that of the foregoing experiments, the conſtituent parts of pure, ductile, vitreous ſilver-ore, taken upon an average, are proved to be:

Silver	85
Sulphur	15
	100

FOURTH SECTION.

Brittle Vitreous Silver-ore.

(Sprödes Silberglanzerz.)

THAT ſilver-ore, which occurs in the Saxon mines, with the name of *ſpröd-glaserz*, and to which the *röschgewächs*, as it is called in Hungary, ſeems to belong, is diſtinguiſhed, as to its external properties, from the ſpecies laſt mentioned, both by its darker colour, and by its brittleneſs, or want of ductility. *Wallerius* and others aſcribe that friability to an admixture of arſenic; but without reaſon, ſince this property is owing to an antimonial ingredient.

For the ſubject of my preſent analyſis, I ſelected the lamellated, friable, vitreous ſilver-ore, from the mine *Alte Hoffnung Gottes*, at *Groſsvoigtbsberg*, near *Freiberg*, which is there found in thin tables, for the moſt part cellularly accumulated, of a black iron-colour, and is aſſociated with a ſort of calcareous ſpar, cryſtallized in low ſix-ſided columns, with trihedral terminations, which is met with in the clefts of a rock of *Gneiſs*.

a) If ductile vitreous ſilver-ore be fuſed upon a piece of charcoal, by the aſſiſtance of the blow-pipe, its ſulphur is quickly volatized, and a button of pure ſilver remains. But it is otherwiſe with the brittle ore: for the bead left after the evaporation of the ſulphur is brittle, and cannot be purified by the addition of borax. However, if a little nitrat of pot-aſh is added to the red-hot bead, it will deſtroy the portion of baſer metal which it contains, and then the borat of ſoda cauſes it to yield a pure button of ſilver.

b) *One hundred* grains of ore, previouſly levigated, were gently boiled in a ſufficient quantity of nitric acid, diluted with an equal quantity of water. This operation was repeatedly performed, till the black colour of the powdered ore diſappeared, and the inſoluble portion had become of a looſe texture, and had acquired a grey-yellow colour. When filtered and dried, this reſidue weighed 26 grains.

c) On adding a ſolution of common ſalt to the above filtered ſolution, which had aſſumed a pale-greeniſh colour, a copious precipitate of horn-ſilver enſued, which, edulcorated and dried, gave 88¼ grains. Four parts of this afforded three of *ſilver*, by fuſion with ſoda.

d) The remaining ſolution was next combined with ſulphat of ſoda; but neither any turbidneſs, nor any indication of the preſence of lead, appeared. Upon this, cauſtic ammoniac was affuſed to exceſs; and the grey precipitate, which then fell down, and which the volatile alkali could not again render ſoluble, weighed five grains. Urged by heat, it melted into a conſiſtence, like pap, at the ſame time that a weak arſenical ſmell was perceived. After this precipitate had been once more diſſolved in nitric acid, the addition of ſoda cauſed it to yield a whitiſh-yellow, alkaline ſulphuret, a dirty brown, and Pruſſian alkali, a deep-blue precipitate, liable to the attraction of the load-ſtone, after ignition. Therefore, it conſiſted of *iron*, with a ſlight trace of *arſenic*.

e) The proportion of copper, indicated by a blue colour, in conſequence of the addition of ammoniac, and which ſtill remained in the ſolution, was but ſlight. For, after the ſolution had been ſaturated with ſulphuric acid, poliſhed iron immerſed in it, was inveſted with ſo ſlight a coppery cruſt, that no copper to any amount could be collected.

f) Thoſe 26 grains, which continued inſoluble in the nitric acid (*b*), were digeſted in nitro-muriatic acid, till nothing appeared to remain but the mere *ſulphur*. Its weight amounted to 13 grains; but, after deflagration, it left behind it about one grain of *quarzoſe matter* of the mine.

g) From this it is obvious, that 13 grains, or one half of the above 26 grains, were held in ſolution by the nitro-muriatic acid; and theſe were precipitated entirely in the form of a white powder, upon the affuſion of 20 parts of water. When ignited, this precipitate aſſumed a yellowiſh colour; but there was nothing, either of arſenic, or any other volatile ſubſtance, perceivable. By combination with ſoda, it became reduced to pure reguline *antimony*; which, as ſuch, admitted of being blown off without leaving any reſidue, in its uſual form of a thick white ſmoke, adhering to the contiguous bodies in the form of needle-ſhaped flowers (*oxyd*) of antimony. Thoſe 13 grains of oxyded antimony are equivalent to ten grains of that metal in the reguline ſtate.

One hundred grains, therefore, of this foliated, brittle, vitreous ſilver-ore, contain:

Silver	*c*)		66,50
Reguline antimony	*g*)		10
Iron	*d*)		5
Sulphur	*f*)		12
Copper and *arſenic*	*d*) *e*)	about	0,50
Extraneous matter from the *mine*			1
			95

Conſidering the minute quantity of arſenic and copper, they can be reckoned only as caſual ingredients; and the ſame holds good with reſpect to the quarzoſe matrix. But, as the antimony exiſts in that ore, intimately combined with the ſilver and ſulphur, it muſt be conſidered as one of its eſſential conſtituent parts.

FIFTH SECTION.

White Silver-ore. (Weiſsgültigerz.)

NATURE has not confined herſelf to one certain determined law, in fixing the proportions that obtain among the conſtituent parts of the *white ſilver-ore*. This fact accounts for the difference of colour, luſtre, and fracture, obſerved in the various ſpecimens of this ore; which alſo, for the ſame reaſon, has been often confounded with the brittle vitreous ſilver-ore, the grey copper-ore, the compact plumoſe antimonial-ore (*dichtes federerz*), and the compact galena, or potter's lead-ore (*bleyſchweif*), &c. It is owing to this difference in the proportions of its component principles, that it is found, at one time, bright, and of a light grey; at another, of a lead-grey, and only glittering; of a fracture compact and even, ſometimes finely grained, or even paſſing into the fibrous texture. Hitherto it has not been met with, except in lumps and diſſeminated.

Of its conſtituent parts, few particulars have been given by former authors. *Henkel** ſeems to be the firſt who enumerates them:—"*Weiſſgültiges Erz*," ſays he, "*is properly a light, or bright-grey ſilver-ore, which yields* 14 *marks of that metal, if it be perfectly pure and compact. It contains, beſides, a little copper, arſenic, and ſulphur, of which, however, it is difficult to aſcertain the proportions.*" It is probably upon this authority of *Henkel*, that late writers unanimouſly ſuppoſe the eſſential ingredients of this ore to be *ſilver*, *copper*, *arſenic*, and *ſulphur*; to which *Cronſtedt*, *Bergmann*, *Kirwan*, and ſeveral others, add *iron*. *Wallerius* mentions two varieties of it: the one *without*, the other *with iron*. *Lehman*, on the contrary, ſuppoſes ſome *lead* inſtead of iron.

Yet, how little theſe ſuppoſed conſtituent parts agree with the real ones, will be manifeſt from the following experiments, made with the two principal ſpecies of the white ſilver-ore.

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* *Henkel redivivus.* Dreſd. 1747. page 57.

A.

Light white ſilver-ore.

a) Among various minerals, dug in the mine *Himmelsfürſt*, behind *Erbisdorf*, near *Freyberg*, I ſelected thoſe that contain the bright white ſilver-ore in ſolid maſſes. From theſe, when pounded, I picked out a ſufficient quantity of fragments, unmixed with the coarſe-cubical galena, which accompanies this ore. It was eaſily levigated, and afforded a blackiſh powder, ſoiling the fingers.

b) Upon *four hundred grains* of this powder, I poured four ounces of nitric acid, of the ſtrength before mentioned, and two ounces of water. After ſufficient digeſtion in a gentle heat, the ſolution was decanted, and the reſidue again expoſed to a warm temperature, with two ounces of that acid. This mixture I next diluted with eight parts of water, and continued to digeſt it for ſome time. I then ſeparated the undiſſolved reſidue, conſiſting of a greyiſh-white powder, which, after waſhing and drying, weighed 326 grains.

c) The ſolution, which was nearly colourleſs, was combined with common ſalt, by which a conſiderable quantity of muriated ſilver was immediately produced. The next day were found over the horn-ſilver, which lay at the bottom of the veſſel, tender needled cryſtals, which, upon cloſer examination, proved to be muriat of lead. On this account I boiled the whole precipitate in a large quantity of water, by means of which the muriated lead was re-diſſolved, and ſeparated from the muriat of ſilver, collected on the filter. This laſt, when reduced by fuſion with ſoda, yielded 81½ grains of reguline *ſilver*.

d) What remained of the ſolution, together with the liquor obtained by the decoction of the horn-ſilver, I evaporated in part; and by adding a ſaturated ſolution of Glauber's ſalt, I obtained from it 45 grains of ſulphat of lead, which, upon reduction, afforded 32 grains of *lead* in the metallic ſtate.

e) The remaining part of the ſolution I now ſaturated with pure ammoniac; upon which a light-brown precipitate fell down, weighing 40 grains, when edulcorated and ignited in a low heat. As that precipitate had the appearance of a mixture of iron and argil, I diſſolved it again in nitric acid, and precipitated, firſt, the iron by means of Pruſſian alkali, and afterwards, by the addition of ſoda, a looſe earth, which, when deſiccated and ignited, weighed 28 grains, and, upon trial with ſulphuric acid, was found to be *aluminous earth*. This, being ſubtracted from the above 40 grains, leaves 12 for the *oxyd of iron*, which may be eſtimated at nine grains of metallic iron.

f) After this, the reſidue, that remained from the ſolution of the ore diſſolved in nitric acid (*b*), was ſubjected to a cloſer examination. I attempted to decompoſe it by muriatic acid, repeatedly poured upon it, and in every inſtance digeſted over it in a heat of ebullition. The proceſs was rendered ſomewhat difficult by the fine needled cryſtals, which were depoſited from the ſolution as ſoon as the heat fell below the boiling point. Similar cryſtals likewiſe ſhot on the paper, through which the ſolution, though yet boiling, was filtered, and I gradually re-diſſolved them again in warm muriatic acid. At laſt there remained 51 grains of ſulphur, leaving, after deflagration upon a teſt, two grains of a grey reſidue, one of which diſſolved in muriatic acid, and was added to the preceding ſolution. The other grain was *ſiliceous earth.* The true quantity of the *ſulphur*, therefore, amounted to 49 grains.

g) While the muriatic ſolution was cooling, it depoſited a quantity of acicular cryſtals. Theſe being ſeparated, one half of the remaining fluid was diſtilled over in a ſmall retort, and, from the ſolution thus concentrated, more cryſtals, ſimilar to the firſt, were depoſited. This treatment was continued until no more cryſtals would form. When theſe cryſtals, collected together, were mingled with twice their weight of black flux, and reduced in an aſſay-crucible, thinly lined with charcoal-duſt, they afforded 160$\frac{5}{8}$ grains of lead. This lead, ſubjected to cupellation, emitted, at the firſt application of heat, a few antimonial vapours; it then fined quietly, and left a *button of ſilver*, weighing $\frac{1}{8}$ of a grain. —This determines the proportion of *lead* at 160$\frac{1}{4}$ grains; from which, however, a trifling quaintity ſhould be deducted for the portion of *antimony* before mentioned; though it could not be well determined, beſides that it could not weigh much above half a grain.

h) The fluid ſeparated from the muriat of lead, concentrated, and covered with a large quantity of water, depoſited its metallic part, which, in the form of a ſubtle, white powder, was only oxyded antimony, and being kneaded into a maſs with ſoap, was reduced in a luted aſſaying-crucible, by means of black flux, into 28$\frac{1}{2}$ grains of pure *reguline antimony.* Some more ſmall globules were found adhering to the lid of the veſſel, of which I collected three grains; but ſtill a ſmall portion appeared to have eſcaped through the joinings, and for this reaſon, the true amount of antimony, which I obtained, may be reckoned at ſomewhat more than the 31$\frac{1}{2}$ grains.

Hence the product of the 400 grains of the *light white ſilver-ore*, here analyſed, conſiſted of:

Silver	*c*)	$81\frac{1}{2}$	$81\frac{5}{8}$ grs.
	g)	$\frac{1}{8}$	
Lead	*d*)	32	$192\frac{1}{4}$
	g)	$160\frac{1}{4}$	
Reguline antimony	*b*)	$31\frac{1}{2}$ grs.	
Iron	*e*)	9	
Sulphur	*f*)	49	
Alumine	*e*)	28	
Silex	*f*)	1	
		$392\frac{3}{8}$ grs.	

Which, in *one hundred* parts, makes:

Silver	20,40
Lead	48,06
Antimony	7,88
Iron	2,25
Sulphur	12,25
Alumine	7
Silex	0,25
	98,09

With reſpect to the argillaceous earth, found in the mixture of this ore, it may be queſtioned: Whether it be merely adventitious, or one of its conſtituent parts. If, at the ſame time, there had been diſcovered in it a proportionate quantity of the ſiliceous earth, they might both together be taken for a clayey matter of the mine, accidentally intermingled with that ore. But, conſidering the wide difference in the proportion of one part of ſilex to 28 of argil, the latter appears to be one of its actual conſtituent parts, though not eſſential.

B.

Dark White Silver-ore.

a) As of late this variety of the white ſilver-ore has but ſeldom occurred in pure maſſes in the Saxon mines, I ſacrificed to analyſis a ſpecimen, which was procured in the year 1720, from the pit *Junger Himmelsfürſt*, at Freyberg, and conſiſted of a ſolid, very pure, white ſilver-ore, of an inch in thickneſs, that croſſed lamellar galena.

b) From *two hundred* grains of this pure ore, finely pulverized, I obtained a colourleſs ſolution by the affuſion of three ounces of nitric acid, and an equal quantity of water. It was at firſt gently digeſted with the ore, then diluted with water, and, after a ſecond digeſtion, ſtrained through the filter. The ſilver, thus diſſolved, was precipitated by means of common ſalt. The muriat of ſilver, thus produced, and dried in a warm temperature, amounted to 24¾ grains, which are equal to 18½ grains of reguline ſilver.

c) Afterwards, on combining this ſolution of the ore with Glauber's ſalt, ſulphat of lead was generated; the quantity of which, when edulcorated and dried, amounted to 93 grains, or to 66 grains of metallic *lead*.

d) Liquid cauſtic ammoniac ſeparated from the remaining fluid a browniſh, looſe precipitate, which, upon ignition, weighed 6½ grains, and, upon farther treatment, yielded 4½ grains of oxyded iron, (equal to $3\frac{1}{2}$ grains of the reguline *metal*), and, beſides, two grains of *aluminous earth.*

e) By adding nitric acid, a greyiſh-white reſidue of $132\frac{1}{2}$ grains was left; which, when extracted with the neceſſary quantity of muriatic acid, left another reſidue of 52 grains; of which, after its ſulphureous parts had undergone a ſlow combuſtion, only eight grains remained. Hence the proportion of *ſulphur* conſiſted of 44 grains.

f) Theſe eight grains, digeſted with muriatic acid, were diſſolved by it, except $1\frac{1}{2}$ grain of *ſiliceous earth.*

g) All the preceding muriatic ſolutions were then ſo far reduced by ſlow evaporation, as to form numerous cryſtals. After cooling, I cauſed the fluid which ſtill remained to drain off from the cryſtals; any foreign matter, that might have adhered to them, I waſhed off with a mixture of one part of muriatic acid, and two of alkohol; and, after deſiccation, I found their weight to be $22\frac{1}{2}$ grains. They conſiſted of *ſulphat* of *lead*, the metallic portion of which amounted to 16 grains.

h) The liquor, ſeparated from them, ſtill contained the *antimonial* ingredient of this ore. By dilution with a ſufficient quantity of water, a white oxyd of antimony was thrown down; whoſe weight, upon drying at an increaſed temperature, proved to be 56 grains, and for which 43 grains of reguline *antimony* muſt be allowed.

It appears, then, that the dark, dull white ſilver-ore contains in *one hundred* parts:

Silver

Silver	*b*)	9,25
Lead	*c*) and *g*)	41
Reguline antimony	*b*)	21,50
Iron	*d*)	1,75
Sulphur	*e*)	22
Alumine	*d*)	1
Silex	*f*)	0,75
		97,25

Conſequently, this analyſis of the above two varieties of the *white ſilver-ore* renders it evident, that it is neither *arſenic*, nor *copper*, but *lead* and *antimony*, which conſtitute the characteriſtic conſtituent parts of this ſpecies of metallic ore; and that the two laſt, for the future, ſhould be mentioned as ſuch.

Though theſe ores are uſually accompanied by galena, the lead found in them ſhould not, on this account, be conſidered as accidental; ſince it there exiſts in intimate mixture. It is a particular and remarkable phenomenon, and an anomaly in our knowledge of the elective attractions of bodies, that, even in the repeated digeſtions of the ore, neither the ſtrong nor dilute nitric acid is capable to diſſolve the whole of the admixed lead, and to deſtroy its combination with the antimonial ingredient.

Modern mineralogiſts have been induced, by the external and ſenſible differences of colour, luſtre, and fracture, which exiſt between the above two varieties of the white ſilver-ore, to regard them as two diſtinct ſpecies, and have introduced the ſecond into the ſyſtematical arrangement as the only genuine white ſilver-ore; ſeparating from it the firſt, which is of a brighter hue, and has been ranked with the brittle vitreous ſilver-ore, treated of at *Sect. IV*.

But as the reaſon for this claſſification was merely founded on ſome varieties of the external characteriſtic properties, it could only ſubſiſt as long as there was wanting a chemical inveſtigatirn of theſe two varieties of the white ſilver-ore, as well as the chemical knowledge of their component principles, which depends on that enquiry.

This deficiency being removed by the preſent analytical proceſſes, and it being demonſtrated that the conſtituent parts of both are of the ſame nature, differing only in their proportions, they ſhould be no longer deſcribed in ſyſtems of mineralogy as particular ſpecies, but only as varieties of *one* and the ſame ſpecies. For this reaſon, the *ſolid, brittle, vitreous ſilver-ore*, as it is called, ſhould be again removed from the claſs of the laſt-mentioned ſpecies, and ſhould reſume the place which it formerly occupied among the *white ſilver-ores*.

SIXTH SECTION.

Grey Silver-ore (Graugültigerz).

That ore of ſilver which I here introduce with this new name, is erroneouſly called *white* ſilver-ore (*Weiſſgülden*), at *Kremnitz* in *Hungary*, where it is dug up both in maſſes and in white quarz. This laſt appellation is the more improper, as, with regard to luſtre and the colour of its fracture, it approaches nearer to the grey copper-ore (*Fahlerz*), than the white ſilver-ore (*Weiſsgültigerz*).

a) *Three hundred* grains of the fragments ſelected from the pounded ore, though not perfectly ſeparable from the quarzoſe gangue, with which they are firmly concreted, were levigated to a ſubtle powder, and digeſted with four times their weight of nitric acid. The digeſtion was renewed with the reſidue, in an equal quantity of the ſame acid; and the portion which ſtill remained undiſſolved then aſſumed a greyiſh-yellow colour, and weighed 188 grains.

b) By the addition of muriat of ſoda to the bright-green nitric ſolution, its ſilver was thrown down; and this precipitate, collected and reduced by means of ſoda, yielded 31¼ grains of metallic *ſilver*.

c) The ſilver being thus ſeparated, I tried the ſolution for lead; but neither the neutral ſulphats, nor free ſulphuric acid, could diſcover the leaſt ſign of it.

d) After this I added cauſtic volatile alkali, ſo as to ſuperſaturate the acid; upon which a brown-reddiſh precipitate, of a looſe coheſion, appeared, that by ignition became of a black-brown, and weighed 9¼ grains. It diſſolved in nitric acid, leaving behind it half a grain of *ſiliceous earth*. Pruſſiat of pot-aſh produced from the filtered ſolution a deep-blue precipitate of iron; and after this was ſeparated, 1½ grain of *alumine* were obtained from it by means of ſoda. Therefore, ſubtracting the ſiliceous and argillaceous earths, the portion of *iron* attractible by the magnet amounted to 7¼ grains.

e) To the ſolution, which had before been over-ſaturated with pure ammoniac, and exhibited a blue ſapphirine colour, ſulphuric acid was now added to exceſs. A poliſhed piece of iron was then immerſed into the fluid, from which it precipitated 69 grains of copper.

f) The above greyiſh-yellow reſidue (*a*) was now to be examined. I digeſted it with ſix times its quantity of muriatic acid in a heat of ebullition. When filtered, the reſidue which was left on the paper being firſt waſhed with muriatic acid, then with a little alkohol, and laſtly dried, was found to weigh 105½ grains.

g) From the ſolution which was obtained by the laſt proceſs, and was of a ſtraw yellow, the greater part of the fluid was drawn off by a gentle diſtillation in a retort. The remaining concentrated ſolution then depoſited ſome cryſtalline grains, which were carefully collected, and proved, upon inquiry, to be muriated ſilver, that afforded a bead of ſilver, weighing ¼ of a grain. A large quantity of water being next poured into the ſolution, a copious precipitate ſubſided, weighing, after deſiccation, 97¼ grains. It proved, by every teſt, to be oxyd of antimony, for which, as I have found by comparative experiments, 75 grains of reguline *antimony* muſt be allowed.

h) The reſidue obtained at (*f*), weighing 105½ grains which compriſed the ſulphureous part of the ore, I expoſed to a low heat, by which treatment the ſulphur was conſumed, and 80¼ grains of ſiliceous earth remained. Hence the quantity of the *ſulphur* was equal to 25¼ grains.

i) The ſiliceous earth was next fuſed with four times its weight of black flux. The melted maſs entirely diſſolved in twice its quantity of water into liquor of flints; ſome minute particles of ſilver, weighing ¼ of a grain, excepted. According to this, the proportion of *ſilex* amounted to 79½ grains.

Whence the conſtituent parts here obtained are:

Sil-

Silver	*b*)	31½	32½ grains.
	g)	¾	
	i)	¼	
Copper	*e*)		69
Reguline Antimony	*g*)		75
Iron	*d*)		7¼
Sulphur	*b*)		25¼
Alumine	*d*)		1½
Silex	*d*)	½	80
	i)	79½	
			290½ grains.

But as the ſiliceous earth does not belong to the real mixture of the ore, but only ariſes from the admixed particles of quarz, it follows, that, when theſe are excluded from the computation, the true conſtituent parts of the grey ſilver-ore here examined, are, in the *hundred*, as follows :—

Silver	14,97 parts
Copper	31,36
Reguline Antimony	34,09
Iron	3,30
Sulphur	11,50
Alumine	0,30
	95,32

As, therefore, the foregoing analyſis plainly ſhews that no lead is contained in this *ſilver-ore* from *Kremnitz*, it cannot be any longer claſſed with the white ſilver-ores. For the ſame reaſon it would be equally improper to reckon it among the grey copper-ores : but, from the conſiderable proportions of noble metal which it contains, it has a juſt claim to the rank of a ſilver-ore, more ſo than even the white and poorer ores of that metal. Therefore, from analogy with the generic appellation, I have given it the name of *grey* ſilver-ore.

When it is conſidered that all the ſilver procured from the ores in Lower Hungary contains a portion of gold, and that this portion uſually amounts to one drachm (4 *denarien*) in the mark of the refined ſilver, which, in *Kremnitz*, is coined into money, there remains no doubt that the ore here analyſed likewiſe contains gold, as, indeed, ſome traces of it appeared in the courſe of this inveſtigation. But it would have required a diſtinct proceſs, performed too with a greater quantity of the ore, to have aſcertained the proportion of gold contained in it; which, however, was beyond the limits of the preſent inquiry.

According to an information given to me as authentic, this ore is ſaid likewiſe to contain mercury. Therefore, though no indication of this metal occurred to me during thoſe experiments, I thought it worth while to inſtitute a particular inquiry on that point. For this purpoſe I mingled 200 grains of the ore with 100 of quick-lime; and having put this mixture into a ſmall retort, connected with a receiver, filled with water, I expoſed the veſſel to the fire, increaſing the intenſity of heat until it became red-hot: but no perceivable trace of mercury appeared.

SEVENTH SECTION.

Native Amalgam of Silver.

Beſides the ſulphurated ores of ſilver, various other metallic mixtures are found in the mineral kingdom, in which the ſilver, unaccompanied by ſulphur, enters as a conſtituent part. To theſe, among others, belongs the ſolution of ſilver in mercury, or the native *ſilver-amalgam*, which occurs chiefly in the quick-ſilver mines, and, in various forms, in the Duchy of *Deux-ponts*.

In order to aſcertain the proportion of theſe two metals to each other, I employed the amalgam, which is found in ſolitary, garnet-like cryſtals in the mine called *Vertrauen auf Gott*, at *Moſchellandsberg*. Some pure cryſtals of this amalgam, weighing together exactly 33⅓ grains, were inſerted into a barometer tube, of a diameter ſomewhat larger than uſual, the lower end of which had been cloſed by fuſion. This end being placed in ſand, within a ſmall crucible, I applied heat to it, increaſing its intenſity gradually and ſlowly to the degree of ignition. After cooling, I cut off the lower end from the tube, and found that it contained the ſilver, which had undergone ignition, in its former cryſtalline form, and weighing 12 grains. On collecting the mercury that had been ſublimed in the tube, I obtained 21 grains. Therefore, ſince the deficiency of ⅓ of a grain may be reckoned as a loſs of quickſilver, the following will be the proportion of the parts in one *hundred* of this *cryſtallized amalgam of ſilver*: namely,

Silver . . .	36
Mercury . . .	64
	100

EIGHTH

EIGHTH SECTION.

Arſenical Silver.

Another example of a metallic mixture, containing ſilver free from ſulphur, is the native *arſenical ſilver*. Its proportion of ſilver varies from a few half ounces to ſeveral marks (of 8 ounces) in the centner, or one hundred pounds. Among the richer ſorts of this ore, I ſelected the ſpecimen, the analyſis of which is here given, and which was dug up from the mine *Samſon*, at *Andreasberg*. Its gangue conſiſts of white, coarſely-lamellated calcareous ſpar, in which the arſenical ſilver is contained, partly in lumps, partly diſſeminated in coarſe grains, but without any other kind of extraneous ores.

a) At firſt I ſeparated from the general maſs, coarſely pounded in the mill, thoſe pieces of calcareous ſpar which contained no portion of metal. Then I continued pouring diſtilled vinegar on the picked ore, till the calcareous ſpar that ſtill adhered was entirely diſſolved and ſeparated. Laſtly, when the ore had again become dry, I reduced it into a fine powder.

b) Upon *two hundred* grains of the ore, thus purified and pulverized, I poured nitric acid of moderate ſtrength, by which it was attacked with great vehemence. When ſufficiently digeſted, the ſolution was ſeparated, by digeſtion, from the dirty yellow reſidue, which, upon drying, weighed 71 grains.

c) On combining it with common ſalt, diſſolved in water, muriat of ſilver precipitated from the ſolution. This horn-ſilver was then freed from moiſture, and fuſed in a ſilver-crucible over a gentle fire; during which proceſs it emitted ſome arſenical vapours. Its weight was 28 grains, equal to 21 grains of *metallic ſilver*.

d) The ſilver being thus removed, I ſaturated the ſolution with vegetable alkali, procured from tartar. A light-red and very intumeſcent precipitate fell down, which, on drying, was rendered of a deep-brown. Ignition made the brown colour diſappear, and the precipitate now exhibited a light greeniſh-grey powder, inclining to white, and which weighed 160 grains. Being convinced that it was arſeniated iron, I put it on a roaſting teſt, mingled with one fourth part of powdered charcoal; and applied a low red-heat. By this treatment the arſenic became revived, and eſcaped in white vapours. The remaining iron was again repeatedly roaſted, with the addition of charcoal-duſt, till no arſenical ſmell could be any longer obſerved. The iron which at laſt remained had a black colour, weighed 106 grains, and perfectly obeyed the magnet.

e) The 71 grains (*b*), that continued undiſſolved in the nitric acid, were digeſted with muriatic acid, and towards the end were once more combined with a few drops of the nitric acid. Nearly all the powder was diſſolved, excepting a ſmall reſidue, coagulated like curds of cheeſe; which proved to be muriated ſilver, and by reduction with ſoda furniſhed a button of *ſilver*, of 4½ grains.

f) By dilution with water, this muriatic ſolution was rendered turbid, without any precipitation. But by ſaturating it with ſalt of tartar, a yellowiſh-green ſediment appeared, which, when collected, dried, and ignited, was found to weigh 32 grains. Upon diſſolving it again in a ſmall quantity of muriatic acid, a white precipitate was produced

duced by the affuſion of water; the quantity of which, when dried in a warm temperature, amounted to 10½ grains. On farther trial, it proved to be unqueſtionably an antimonial oxyd; ſtill containing, however, a ſlight trace of arſeniated iron. I eſtimate that oxyd at 8 grains of *reguline antimony.*

g) What remained of the muriatic ſolution afforded, by combination with the above vegetable alkali, a precipitate, which, when dried and roaſted, like the preceding (*d*), with pulverized charcoal, yielded 18 grains of *oxyded iron.*

h) Deſirous of aſſuring myſelf of the abſence of ſulphur, I ſubjected 200 grains of the powdered ore to ſublimation, in a ſmall retort. Nothing but pure reguline arſenic was raiſed; which, as uſual, fixed in the neck of the retort, in the form of a cruſt of a metallic luſtre, compoſed of an accumulation of ſmall cryſtals.

i) It is then evident, that this ore conſiſts of ſilver, iron, arſenic, and antimony. However, when we reflect that the arſenic, during the treatment of the ore with acids, combines with oxygen; and farther, that part of it is driven off in the oxyded ſtate, on the proceſs of roaſting, and that part of it is taken up by the water employed for waſhing the precipitates, the acid of arſenic being of eaſy ſolution in water, it is obvious that there exiſts a degree of uncertainty in the attempt to aſcertain, with accuracy, the proportions in which thoſe ingredients are united. Nevertheleſs, the proportion of arſenic may be computed, with propriety, from the loſs of weight requiſite to make up the whole weight of the three remaining conſtituent parts, in the following manner:

Silver *c*)	21		25½
e)	4½		
Iron,			
Oxyd of iron attractible by the magnet *d*)	106	124	
g)	18		
which gives of metallic iron			88½
Reguline antimony			8
			122
The arſenic, therefore, would make (200—122=78)			78
			200

However, ſince, in the proceſſes of chemical analyſis of this as well as of other ſpecies, ſome loſs always unavoidably occurs in the ſum of the products, amounting from 2 or 3 to 5 or 6 in the hundred, regard muſt here be had to this circumſtance. Therefore, if the mean number of the loſs, which is 4, be ſubtracted, 70 will be left for the arſenic.

Hence, according to theſe premiſes, the *arſenical ſilver* examined in this analyſis contains, in an hundred parts,

Silver	12,75
Iron	44,25
Arſenic,	35.
Reguline antimony	4
	96

Beſides the above eight ſpecies of ſilver-ores, the analyſis of which have made the ſubject of the preſent eſſay, other kinds of argentiferous ores and metallic mixtures occur. But the greateſt part of theſe cannot be fairly conſidered as ſpecies of the genus of ſilver-ores; becauſe the proportion of the noble metal which they contain is too inconſiderable, when compared with their other conſtituent parts.

In general, I ſhould not wiſh to recommend the method hitherto uſed in the ſyſtematic arrangement, of denominating ores by the conſtituent part, which is of the greateſt mercantile value; though, on the other hand, I do not venture to aſſert, that, at the preſent period, the *predominant conſtituent part* alone ſhould ſerve as the principle, upon which to eſtabliſh the claſſification of foſſil bodies. If it were ſo, we ſhould only retain under the genus of ſilver (beſides the *native ſilver*) the *corneous*, the *red*, the *vitreous*, and *brittle vitreous ſilver-ores*; together with the black ſilver-ore (*ſilver-mulm*), which I had no opportunity to examine. And, on the contrary, the *white ſilver-ore* would then neceſſarily come under the genus of lead; the *grey* under that of antimony; the *ſilveramalgam* under that of mercury; and the *arſenical ſilver* under the genus of iron.

It is only by increaſing our knowledge of the chemical compoſition of individual ſpecies of foſſils that we ſhall be able to erect, on the relics of the preſent ſyſtem of mineralogy, another, which ſhall poſſeſs a more ſolid foundation, and ſhall be more conformable to nature.

X.

EXAMINATION

OF THE

ORIENTAL LAPIS LAZULI.

THOUGH the reſearches of Marggraf have refuted the opinion, formerly received, that the blue colour of the *Lapis Lazuli* originated from an admixture of copper; and though it has been demonſtrated that the colour of this foſſil is owing only to iron, yet its other conſtituent parts have not yet been determined with due accuracy. For this reaſon, I thought that a farther examination of it would not be ſuperfluous.

Marggraf[*] mentions, indeed, and very juſtly, *lime*, *gypſum*, and *ſilex*, as the other conſtituent parts of the lapis lazuli, beſides a quantity of *iron*: but this account is ſtill incomplete, as he takes no notice of their reſpective proportions, and has, beſides, entirely overlooked the *aluminous earth* which it contains.

Rinmann[†] aſſures us, that this ſtone, beſides iron, calcareous earth, and quarz, contains alſo *fluoric acid.* Nevertheleſs, I could not aſcertain the preſence of the latter. *Rinmann*'s ſuppoſition was probably occaſioned only by the phoſphoreſcent light which iſſues from the lapis lazuli, when heated.

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[*] *Marggraf*, Chim. Schriften I. Theil. Berlin, 1768, page 121.

[†] *Rinnmann*, Geſchichte des Eiſens, 2 B. Berlin, 1785, page 136.

Cronſtedt, and others likewiſe, ſuppoſe the exiſtence of ſilver in this mineral, amounting to two *ounces* in 100 *pounds*; but neither could I diſcover any clear indication of this ingredient. I choſe, for the following inquiries into the nature of the lapis lazuli, a pure ſpecimen of a deep-blue; and I firſt endeavoured, as much as poſſible, to free the fragments from the white ſpots, and the particles of ſulphur-pyrites with which this ſtone is always mixed.

a) *Hundred* parts of lapis lazuli loſt two parts in weight, by being ignited for half an hour in a porcelain crucible. Its colour ſuſtained no change.

From this conſiderable permanence of the beautiful blue colour, I was induced to try whether it would admit of being employed as an enamel colour, eſpecially as *Bergmann* had already conjectured that the Chineſe and Japaneſe probably uſed the lapis lazuli to impart the blue colour to their porcelain. With this view, I cauſed the powder, finely ground with a ſuitable flux, to be put upon porcelain, and had it baked in an enamelling furnace. My expectation, however, proved abortive; for the colour was altered, and had paſſed to an aſh-grey.

b) But in a ſtronger and more continued fire, the lapis lazuli becomes completely vitrified, and loſes 12 *per cent*; as has been already mentioned in No. 51 of my Eſſay *on the Habitudes of various Species of Earths and Stones in Fire*. The two parts that eſcaped from the hundred, during ignition for half an hour, cannot well be taken for any thing elſe than water. But the other 10 parts, which the ſtone loſes in a more intenſe heat, probably conſiſt of carbonic acid; ſince the efferv eſcence of the lapis lazuli, when covered with any acid, weak as it is, ſhews that a part of its calcareous ingredient is diſſolved in that menſtruum.

c) *Two hundred* grains of finely levigated lapis lazuli were digeſted in a retort with muriatic acid, weakened by an equal quantity of water. The blue colour of the pulverized ſtone gradually turned to aſh-grey. When the mixture had reached a boiling heat, the powder was acted on with greater vehemence by the acid, and, after ſome ebullition, it formed a cheeſy-coagulum. I then diluted it with more water, added one part of nitric acid, and kept it boiling till the inſoluble reſidue had aſſumed a white colour. The ſolution, afterwards ſeparated by filtration, was of a pale yellow.

d) The reſidue had a ſandy appearance, and weighed 138 grains after drying. It was ſubjected to ignition with three parts of cauſtic, or pure pot-aſh. The greeniſh maſs which reſulted thence, when ſoftened with water, afforded a colourleſs ſolution, from which muriatic acid, added to exceſs, precipitated *ſiliceous earth*, weighing 57 grains when ignited.

e) This ſame ſolution (*d*), mixed with the above (*c*), and decompoſed in a boiling heat by carbonat of pot-aſh, yielded a yellowiſh-white precipitate, which, upon deſiccation, weighed 221 grains, and entirely diſſolved in muriatic acid.

f) Cauſtic ammoniac threw down from this ſolution a gelatinous precipitate, which, when digeſted with cauſtic alkaline lye, was not totally diſſolved, but left a yellowiſh-white reſidue, of 113 grains, in its dry ſtate.

g) By combining the liquid that remained from the precipitation by ammoniac, with carbonat of pot-aſh, in a boiling heat, 59 grains of carbonat of lime, or mild *calcareous earth*, were obtained.

h) Upon the 113 grains, not taken up by the cauſtic lye, I poured dilute ſulphuric acid. The mixture coagulated in heat to a gelatinous conſiſtence. When covered, and digeſted with a large proportion of water, there ſeparated from it *ſiliceous earth*, the quantity of which, after being heated to redneſs, was 29 grains.

i) After the ſilex had been ſeparated, the ſolution was mixed with ammoniac, and the precipitate thus formed was conveyed, while yet moiſt, into boiling cauſtic lye. A brown flocculent precipitate remained, which weighed, when dry, 13 grains. After they had been diſſolved in muriatic acid, cauſtic ammoniac precipitated *oxyd of iron*, weighing 6 grains. After deſiccation, by adding carbonated ammoniac to the remaining fluid, 5 grains more of *calcareous earth* were thrown down.

k) The alkaline ſolution (*f*) and (*i*) were then ſaturated with muriatic acid. By this all that the alkali had taken up was ſeparated; and this, when re-diſſolved, by an additional portion of the ſame acid, I again precipitated by carbonated pot-aſh. On re-diſſolving this laſt precipitate, in dilute ſulphuric acid, there appeared another portion of ſilex, which, after ignition, was found to weigh 6 grains. The ſulphuric acid, when poured off, and combined with a due proportion of pot-aſh, afforded cryſtals of alum, which were re-diſſolved, and their *aluminous earth* precipitated by

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by means of mild, or carbonated alkali. After the alumine had been properly purified, deſiccated, and expoſed to red heat, its weight amouted to 29 grains.

l) I had before convinced myſelf, that in the lapis lazuli the whole of its calcareous earth is not combined with carbonic acid, but a portion of it with the ſulphuric acid. For this purpoſe I boiled a portion of pulverized lapis lazuli with a large quantity of water; which, when filtered, had an opaline appearance. Muriated barytes being then added as a teſt, ſome ſulphat of barytes was formed. In order to diſcover the proportion of the ſulphat of lime, or gypſum, contained in this ſtone, I took the fluid remaining from the precipitate mentioned at (*c*), together with the edulcorating water, and, after ſuper-ſaturation with muriatic acid, I examined it with a ſolution of muriat of barytes. The reſult was a precipitation of ſulphat of barytes which, collected and highly dried, amounted to 19½ grains.

It was reaſonable to conjecture, that not only the gypſum contained in the lapis lazuli, but alſo an accidental admixture of ſulphat of pot-aſh, in the cauſtic and mild alkali employed in the proceſſes (*d*) and (*e*), might have contributed to the formation of the ſulphated barytes. Therefore, to aſcertain this point, I diſſolved a ſimilar quantity of each, adding then muriatic acid, ſo that the acid predominated; and, laſtly, I combined the whole with muriat of barytes, In the reſult, there appeared 1½ grain of ſulphat of barytes. collected with care. An equal quantity, therefore, is to be deducted from the above 19½ grains. On this account, the above-mentioned 18 grains of ſulphated barytes were the proper ſcale, or meaſure, by which to determine the proportion of the gypſum ſought for in the preſent inſtance; and, calculating upon this ground, it followed, that the above 200 grains of decompoſed lapis lazuli contained

8,18 grains of free ſulphuric acid of 1,850 *ſpec. grav.*; or, if taken in combination with the lime which enters into that ſtone, 13 grains of gypſum. This computation is founded on the reſults of my experiments: *firſt*, that, diſregarding minute fractions, 100 parts of ſulphuric acid of the above-mentioned ſpecific gravity, when ſaturated with barytes, yield 220 of ſulphat of barytes; and, *ſecondly*, that the ſame quantity of ſulphuric acid, when ſaturated with calcareous earth, forms 160 parts of gypſum: obſerving, however, that 100 parts of crude calcareous earth, or carbonat of lime, are required to ſaturate the acid; but only 55 parts of pure, or burnt lime.

Conſequently, theſe 200 grains of *Lapis Lazuli* give the following *remote conſtituent parts*:

Lime	*d*)	57	92 grains.
	b)	29	
	k)	6	
Silex	*g*)	59	
	i)	5	
		64, ignited	35
Alumine	*k*)		29
Oxyd of iron	*i*)		6
Sulphuric acid	*l*)		8
Carbonic acid	*b*)		20
Water	*a*)		4
			194
		Loſs	6
			200 grains.

But ſince the calcareous earth, in the preſent ſubject of inquiry, is combined partly with ſulphuric acid, partly with the carbonic, the following muſt be reckoned as the *proximate conſtituent parts* of the lapis lazuli:

Silex	46
Alumine	14,50
Carbonat of lime	28
Sulphat of lime (gypſum) . .	6,50
Oxyd of iron	3
Water	2
	100

The reaſon of this exact agreement of the ſum of the conſtituent parts with the weight of the whole, is, that I have ſuppoſed the carbonat of lime to be *completely* ſaturated with the carbonic acid; which, however, does not ſeem entirely to be the caſe.

XI.

XI.

EXAMINATION OF A SMALT-BLUE FOSSIL, *from Vorau*[*]

AMONG the mineralogical notices, given in a letter from Vienna, inſerted in the third volume of the *Obſervations and Diſcoveries in Natural Hiſtory*, page 352, mention is made of a newly-diſcovered blue foſſil from *Vorau*, in Auſtria. It was, at firſt, taken for *native ſmalt*, then for native *Pruſſian-blue*, and, laſtly, for *mountain-blue*, or azure copper-ore.

This foſſil is of a deep ſmalt-blue, accompanied with a grey-white quarz, of an imperfectly conchoidal fracture, *(Fettquarz)*, with which it is firmly concreted, and croſſed by a band of *ſhiſtoſe mica*, from ¼ to ½ inch thick, conſiſting of grey-white granular quarz, and a little mica of a ſilvery-white. It partly forms the ſeam, or joint *(ſalband)* of this ſmall vein; partly it is finely diſſeminated through the quarz, and ſometimes it approaches to the ſize of a hazel-nut. When in the latter ſtate, a cryſtalline form of quadrilateral flattened columns, or tables, is obſerved; though, on account of the quarz, which is perfectly concreted with it, the exterior, unbroken ſurface only, in ſome parts, exhibits the cryſtalline form. On theſe facets the foſſil is even, and of a moderate luſtre; but in the fracture, which is compact and rough, it is only glittering. It is opake; its ſtreak of a ſomewhat lighter blue; its hardneſs nearly that of quarz.

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[*] *Beobachtungen und Entdeckungen aus der Naturkunde* 4 Band. Berlin, 1792. Seite 90.

No ſign of any volcanic product preſenting itſelf in this foſſil, it was obvious, from the very mode of its appearance, that it could not, by any means, be a native ſmalt: for, muſt not the agency of fire have been preſent, to form a ſtony matter, naturally coloured blue by means of *cobalt?*

The following ſhort narrative of my reſearches concerning this foſſil, will alſo prove, that it is as far from being a *mountain blue*, or containing oxyded *copper*; notwithſtanding that this is given as the reſult of the chemical experiments made with it at Vienna.

Finding that all the acids which I poured upon this mineral, previouſly reduced into fine powder, and freed as much as poſſible from the aſſociated quarz, would not attack it with the requiſite force, I ſubjected it to a low red-heat, combined with twice its weight of pot-aſh, procured from tartar. After refrigeration, I obſerved that the blue colour had entirely diſappeared, and the maſs had aſſumed a yellowiſh-white. When this had been triturated, ſoftened in water, then ſaturated to exceſs with nitric acid, digeſted and filtered, there remained undiſſolved *ſiliceous earth.* The ſolution had no colour. In one part of it I immerſed poliſhed iron; but neither copper, nor any other metallic ſubſtance would precipitate. To the remaining portion pruſſiat of pot-aſh was added, and thus a deep-blue precipitate was produced, which, after ignition, was attracted by the magnet. From the ſolution, ſeparated from this laſt by filtering, liquid cauſtic ammoniac threw down ſome *aluminous earth* in a ſlimy ſtate. But the remaining fluid ſuffered no change, on the addition of carbonat of pot-aſh.

Silex, *alumine*, and *oxyded iron*, are then the conſtituent parts here diſcovered. But their reſpective proportions remain to be aſcertained by new experiments, to be performed with a greater quantity of this foſſil.

As, therefore, not the ſlighteſt trace of copper can be found in this foſſil, it is obvious that it cannot in any reſpect be conſidered as a mountain-blue.

Nor can I take it for a native Pruſſian blue, which it was conſidered to be, in conſequence of an inquiry made into its nature at Chemnitz. Its portion of iron affords no argument to the contrary; and the grounds of my opinion reſt upon the following obſervations.

1. *a*) The native Pruſſian blue is found only in mooriſh grounds or fens, and in thin ſtrata. It occurs immediately under the vegetable mould, and appears in the form of a looſe white earth, that becomes blue only when expoſed to air.

b) This blue foſſil, on the contrary, is concreted with a hard vein of quarz, which is incloſed in a ſtony matter of equal hardneſs. Beſides, its blue colour ſhews itſelf directly on every recent fracture; which indicates that the foſſil was previouſly poſſeſſed of it.

2. *a*) Native Pruſſian blue is immediately deprived of its colour by fire; at firſt it becomes brown, then of a brick-red, and laſtly it melts into globules of a metallic luſtre.

b) The foſſil from Vorau falls inſtantly in pieces, when urged by the fire. Its coheſion is thereby looſened, and it aſſumes the form of a light-grey flocculent earth; but without ſhewing the leaſt diſpoſition to fuſe.

3. *a*) With borat of ſoda, and with the phoſphats, the native Pruſſian blue runs into a black untranſparent ſcoria.

b) But the foſſil from Vorau yields, when fuſed with borax, a clear, faint, topaz-yellow glaſs; and with a neutral phoſphat*; a clear, colourleſs glaſs.

4. *a*) The native Pruſſian blue directly liquefies in acids, when poured upon it.

b) On the contrary, the foſſil from Vorau is with difficulty acted upon by acids.

5. *a*) Cauſtic alkaline lye inſtantaneouſly changes the colour of the native Pruſſian blue into a brown.

b) But the colour of the above foſſil is not at all altered by it.

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* The author conſtantly uſes the expreſſion *Phoſphorſalz*, whereby *concrete phoſphoric acid* might be underſtood: but moſt probably he means a neutral phoſphat, and eſpecially the *phoſphat of ſoda*, which, on account of its property of promoting fuſion in an eminent degree, is chiefly employed by mineralogiſts and chemiſts in examining ſubſtances with the blow-pipe.—Hence, the tranſlator ſubſtitutes, in all ſimilar caſes, the term *neutral*, or *alkaline phoſphat*. Tranſ.

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In the native Pruſſian blue, the oxyd of iron is combined with phoſphoric acid; as I have proved in another place*. But it is ſtill unknown, by what ſubſtance the oxyd of iron, contained in the foſſil from Vorau, is modified ſo as to acquire the blue colour.

Another inſtance of a ſimilar blue colour imparted by iron, is afforded by the *Oriental lapis lazuli*. It differs, however, from the preceding, in this, that its blue colour is conſiderably more permanent in the fire; for, ſo long as the ſtone is but moderately ignited, its colour continues unaltered, and is changed only when the ſtone is urged by a ſtronger heat, and is brought into the ſtate of fuſion. The lapis lazuli is alſo diſtinguiſhed from the foſſil from Vorau, beſides its other conſtituent parts, by a proportion of calcareous earth, which is the cauſe of its melting in fire.

If the above foſſil likewiſe contained lime, I ſhould not heſitate to range it as a variety of the lapis lazuli; as has been already done by Mr. *Stütz* †, with the name of *ſpurious lapis lazuli*. Perhaps may the denomination *lazulite* be not quite improper.

Note. I have once mentioned that foſſil, as a particular ſpecies of ferruginous earth, or oxyded iron, with the name of *iron-blue from Vorau*; but its proportion of iron ſeems to be too ſmall to entitle it to that place.

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* Chemiſche Annalen. 1784. 5tes Stuck. Seite 396.

† *Neue Einrichtung der K. K. Naturalienſammlung zu Wienn.* Wienn, 1793. Seite 49.

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XII.

CHEMICAL EXAMINATION

OF THE

CIRCON, OR JARGON OF CEYLON.

*FIRST SECTION**.

AMONG the rough or uncut precious ſtones coming from Ceylon, there occurs a particular genus, hitherto little noticed; which is diſtinguiſhed from other gems by the following characters.

Its colour conſiſts of various ſhades of pale yellow-green, and reddiſh, altogether inclining to a dim ſmoke-grey. Externally, a greaſy gloſs is obſerved, and it feels ſmooth. The ſize of the individual ſtones is inconſiderable; commonly 20 or 30 of them weigh only one drachm. The primitive figure of their cryſtals is a rectangular four-ſided column (*parallelopipedon*), with tetrahedral terminations, the ſurfaces of which reſt on thoſe of the column. However, this form of cryſtallization is diſtinctly perceptible in very few ſpecimens only; as for the greateſt part they are merely looſe, minute, rounded grains (*abgerundete geſchiebe*[*].)

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* *Auszug aus den Beob. u. Entdeck. aus der Naturkunde.* 3 B. 2 St. Berlin, 1789.

But this kind of gems is eminently diſtinguiſhed by its ſpecific gravity, which I have found to be 4,615[†].

Romé de l'Iſle was the firſt, to my knowledge, who mentions theſe gems as a particular ſpecies of ſtones; giving them the name, *Jargon of Ceylon*, and ſtating their weight, according to *Briſſon*'s experiments, at 4,416. Other mineralogiſts and writers, who notice this ſtone, claſs it—ſome with the ſapphire, others with the topaz, others with the ruby, others with the diamond, and ſome with the hyacinth. But *Werner* has aſſigned to it a peculiar place in the mineralogic ſyſtem, immediately under the diamond, and the chryſoberyl, and called it *Zircon* (*Silex cirnonius.*)

The jargons do not loſe much of their weight by ignition; for, upon igniting 300 grains for the ſpace of one hour and a half, and with the greateſt intenſity of heat, I found the loſs to be only one fourth of a grain. This ignition I repeated three times, and quenched them after each proceſs in water. The ſtones became by this rifty: the brighter ones loſt their ſmoke-grey appearance, and were rendered ſimilar to cloudy white-grey quarz; but ſome of the darker ſpecimens, as well as ſome parts of the brighter, turned reddiſh. Their natural hardneſs, however, did not ſeem to have been impaired.

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[*] A more circumſtantial deſcription has been given by *Emmerling*, in his *Lehrbuch der Mineralogie, I. Th. Gieſſen*, 1793; and by *Widenmann*, in his *Handbuch der Mineralogie, Leipzig*, 1794.

[†] Yet I have afterwards found a difference in the ſpecific gravity of the various ſpecies; however, the leaſt weight that I obſerved was as high as 4,530.

A.

a) By way of a preparatory analyſis, 200 grains of jargon were levigated in a flint-mortar to a very ſubtle powder of a white colour, inclining to a pale fleſh-red, which I mingled with equal parts of carbonated pot-aſh, expoſing it to a red-heat for one hour in a ſilver-crucible. It then formed a conglutinated maſs, which, upon trituration, I ſaturated to exceſs, and digeſted with muriatic acid. But this did not at all appear to attack it, as I obtained again the jargonic powder without the leaſt alteration, and with the loſs of only half a grain.

b) For this reaſon I afterwards blended the ſame powder with ſix times its quantity of the above alkali, prepared from tartar, and ignited it ſtrongly during five hours. The maſs was rendered compact, and brought to the point of fuſion: yet, when ſoftened with water, and digeſted with muriatic acid added to exceſs, the powder of the ſtone was likewiſe found but little altered; and, after waſhing, drying, and ignition, I recovered it with no more loſs than two grains.

c) Upon this, I once more added 1200 grains of the above alkali, and kept the maſs in an ignited ſtate, until it actually fuſed; which, after being again ſuper-ſaturated with muriatic acid, left behind it 197 grains of undecompoſed jargon.

d) I next put this powder into a retort, and poured upon it five times its quantity of ſtrong ſulphuric acid, adding to it one ounce of water; and when the liquor had been diſtilled off to dryneſs, I ſoftened the reſidue with water. But even by this proceſs the ſtone underwent no obſervable change. The reſidue, when lixiviated and dried, reſembled, as before, a fine ſandy powder, and weighed 196 grains. From the acid fluid, ſaturated with alkali, one grain of a white earth fell down.

The obſtinacy with which the jargon reſiſted every attempt to decompoſe it in the above manner, abated my ardour in purſuing farther this experiment. But, having in the mean time become acquainted with the powerful efficacy of cauſtic fixed alkalis in looſening the coheſion of particles in the various ſpecies of gems, I reſolved to employ them alſo for the jargon, and proceeded to the following new experiment.

B.

a) *Two hundred grains* of finely pulverized jargon were ignited for two hours in a ſilver-crucible, with four times their weight of cauſtic ſoda, and with ſuch an intenſity of heat, that the maſs continued in a ſtate of pulpy or thick fuſion. Upon refrigeration, the maſs proved to be very hard, and was gradually ſoftened by repeated affuſion of boiling water. The alkali ſeemed to have totally loſt its former cauſticity, the ſolution taſting like a weak carbonated lixivium. When it had been ſufficiently ſuper-ſaturated and digeſted with muriatic acid, I did not obſerve that any ſiliceous earth ſeparated; and the undiſſolved reſidue remained behind on the filtering paper in the form of a fine ſand-like powder, weighing, after deſiccation and ignition, 172 grains.

b) That reſidue, when again treated in the ſame manner with four times its weight of cauſtic ſoda, afforded a very firm porous maſs, which, after being digeſted with muriatic acid, in the manner related, left behind 148 grains of jargonic powder.

c) The ſame proceſs of adding to it four times its weight of cauſtic ſoda, and ſubſequent digeſtion in muriatic acid, was repeated with this laſt. After this treatment, there ſtill remained 127 grains.

d) This, treated again for the fourth time in the ſame manner, left 97 grains.

e) As my ſtock of cauſtic ſoda was now exhauſted, I prepared, inſtead of it, a cauſtic vegetable alkali, and added to the above undecompoſed 97 grains of jargon ſix times their weight of the above alkali, and kept the maſs, during ſeveral hours, in as intenſe an ignition, as the ſilver-crucible was able to bear without melting. However, its fuſion went on but ſlowly, and was of a pulpy conſiſtence. Even boiling water would but difficultly liquefy the refrigerated maſs. But, when it had been ſaturated to exceſs, and digeſted with muriatic acid in the degree of boiling heat, a total ſolution of the jargon enſued.

f) I now poured together all the ſeveral preceding ſolutions. The whole of them exhibited a tranſparent fluid, but ſomewhat opaleſcent, and with a few light flocculent particles floating in it. I then ſaturated this liquor with carbonated, or mild pot-aſh. The earth, which ſeparated by this management, gave to the mixture an appearance of milk. But when collected on the filter, and waſhed, it firſt aſſumed the form of paſte made of ſtarch, and afterwards dried up to lumps of a vitreous appearance, and of a whitiſh colour, verging upon the grey-green. The fluid filtered off from it, together with the waſhings, ſtill depoſited in a warm temperature a ſmall portion of earth, which I added to the above precipitate.

g) This precipitate contained now all the conſtituent parts of the jargon under examination, but deprived of their native coheſion. *One half* of it I digeſted with one ounce of ſtrong muriatic acid, in a heat of conſiderable intenſity, and thus I obtained a turbid yellowiſh ſolution, from which the undiſſolved part ſlowly ſubſided upon dilution with water. After the ſuperincumbent liquor had been decanted, and the reſiduum digeſted with an equal quantity of boiling muriatic acid, I filtered the ſolution, and dried the undiſſolved reſidue, which ſtill remained.

h) As, in this inſtance, it was my principal deſign to diſcover, whether any calcareous earth was preſent, I precipitated the diſſolved portion from the muriatic ſolution by means of cauſtic ammoniac. It fell down as an extremely looſe ſubſtance, reſembling a tranſparent ſlime. But neither carbonated ammoniac, nor carbonated pot-aſh, would produce the leaſt turbidneſs, when added to the ſeparated clear liquor. This ſhews, that it contained no calcareous earth; which was alſo confirmed by ſeveral other teſts or re-agents employed for that purpoſe.

i) Upon the *ſecond half* of the above precipitate (*g*) I affuſed a triple quantity of concentrated ſulphuric acid, and abſtracted it again by diſtillation to dryneſs. From the reſidual maſs again ſoftened with water, and which looked like diſſolved ſtarch, I ſeparated the undiſſolved part by filtration. But the filtered ſulphuric ſolution, which was as limpid as water, when combined with various precipitating media, exhibited preciſely the ſame phenomena with thoſe ſhewn by the foregoing ſolution, prepared with muriatic acid.

k) The whole of the earth, which remained from both ſolutions (*g*) and (*i*), weighed, after ignition, 86½ grains, and reſembled a fine ſandy powder. It was then mingled with four times its weight of carbonated pot-aſh, and ſubjected to ignition in a ſilver-crucible, until it entered into complete fuſion. When the maſs was again ſoftened in water, it was found ſtill hard, and of difficult ſolution. However, a very ſubtle, heavy, and, apparently, tenacious earth, was depoſited, which, collected and ignited, was found to weigh 28½ grains.

l) The clear and colourleſs alkaline lixivium I divided into two parts. *One half* of it I ſaturated with muriatic acid; by which treatment, a white, puffy, gelatinous earth ſeparated, no portion of which, however, would re-diſſolve, by adding a ſuperabundant quantity of the ſame acid. The *other half* I firſt diluted with plenty of water, and then gradually ſaturated it to exceſs with muriatic acid. It continued clear and limpid; and by this I was convinced, that the above was *merely ſiliceous earth*; which, therefore, after deducting the 28½ grains of earth from the 86½ grains that were fuſed with the pot-aſh (*k*), amounted to 58 grains.

Note. This is the order of examination in which I proceed, with reſpect to thoſe earths, which, on analyſis, I have ſome reaſons to conſider previouſly as belonging to the ſiliceous genus. By this method I moſt ſurely avoid the error, perhaps not unfrequent, of immediately calling any earth, that on the firſt attempt does not appear to diſſolve in acids, merely ſiliceous. I likewiſe largely dilute with water the alkaline ſolution of the ſiliceous earth, and combine it to exceſs with any acid—(in which caſe, however, no precipitate enſues, becauſe the ſiliceous earth thus circumſtanced is really ſoluble in water.)—And when upon this I evaporate it to dryneſs, with the aſſiſtance of heat, and ſoften again the dry ſalt with water, I find the ſiliceous earth, that was before held in ſolution, at the bottom of the veſſel, in the form of fine cryſtalline grains of ſand.

m) Thoſe 28½ grains of earth, that were left behind on the treatment with alkali (*k*), I digeſted in a boiling heat, with an abundance of nitro-muriatic acid. A reſidue was left, weighing, upon ignition, 16 grains.

n) Theſe undiſſolved 16 grains, blended with ſix parts of cauſtic pot-aſh, were expoſed for ſome hours to a red heat. The colourleſs fluid, which was filtered off from the maſs when again liquefied with water, was not rendered turbid by the addition of ſulphuric acid. But when expoſed to a raiſed temperature, it formed a gelatinous maſs, which, after thorough deſiccation, and the ſeparation of the remaining ſalt by ſubſequent affuſion of water, left three grains of *ſiliceous earth* behind, in the form of ſand.

o) The remainder of the alkaline ſolution (*n*), was ſubjected to digeſtion with boiling aqua regia. The earth, contrary to cuſtom, ſwelled into a ſlimy matter, and the liquor acquired a greeniſh tinge. I filtered the ſolution previouſly diluted with water; mixed it with the preceding, which was likewiſe prepared with nitro-muriatic acid (*m*), and added pruſſiat of pot-aſh. The greyiſh-green precipitate thus produced, when heated to redneſs, weighed no more than half a grain. The portion of *oxyded iron*, thus detected in the jargon under examination, may therefore be eſtimated at one fourth of a grain.

Note. Some phenomena which appeared on examining this precipitate, obtained by means of pruſſiated pot-aſh, led me to ſuſpect

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ſuſpect a ſlight trace of the preſence of Nickel. However, ſince, on every ſubſequent examination of the jargon, no ſuch indication any more occurred to me, I think the above appearance to have been merely accidental.

p) Carbonated vegetable alkali, being then added to the nitro-muriatic ſolution, precipitated of a white colour the remaining portion of earth, which it ſtill contained. This earth, upon examination, was found to be of exactly the ſame nature with that obtained from the firſt ſolutions.

q) After the reſidual undiſſolved earth had been ignited, it weighed five grains. I conſider this as the remainder of the rough jargon, which had eluded the attempts to decompoſe; it the farther analyſis of which, from the minuteneſs of its quantity, could not be undertaken.

C.

I now proceeded to the cloſer examination of that part of the jargon, which was found to be ſoluble in acids.

a) According to the eſtabliſhed rule, the above ſulphuric ſolution (B. *i*) ſhould be ſuppoſed to contain either magneſian, or aluminous earth, or a mixture of both. However, the taſte gave not the leaſt indication of either. On the contrary, it was hardly diſtinguiſhable from that of pure ſulphuric acid, and but gently aſtringent. In endeavouring to cryſtallize it, I expelled a part by evaporation, combined the remainder with a proportionate quantity of pot-aſh, and waited to ſee whether aluminous cryſtals would form. It is true, on farther evaporation, there ſeparated a cryſtalline milk-white cruſt; which, however, could not be taken for alum, but only ſulphat of pot-aſh, together with which a portion of the diſſolved earth was depoſited.

b) To carry the experiment farther, I diſſolved the above-mentioned ſaline ſediment in water; and in order to collect the whole quantity of the jargonic earth, I likewiſe diſſolved that portion of it, which I had recovered from the muriatic ſolution (B, *g*), by means of ammoniac, as well as that which I had precipitated by vegetable alkali, from the nitro-muriatic ſolution (B. *p*). Both theſe laſt I diſſolved in dilute ſulphuric acid, and added the ſolutions to the preceding.

c) I now once more directed my attention to the metallic ingredient in the jargon, to detect which, I could employ only the pruſſiat of pot-aſh. The firſt portion which was added, produced in the colourleſs ſolution a dirty olive-green; but ſubſequent additions, made by degrees, tinged the mixture of a deep-blue. After the blue precipitate had ſubſided, it was collected and dried. It weighed three grains; of which the proportion of *iron* may be eſtimated at a fourth part, that is, three fourths of a grain.

d) Upon this I ſaturated the whole of the ſulphuric ſolution with cryſtallized alkali, prepared from tartar; on which the earth, which ſeparated, imparted to the mixture an uniform, milky appearance. The earth thus depoſited and waſhed, was ſubjected, while yet moiſt, to the following experiments.

e) In diluted and gently warmed ſulphuric acid it diſſolved without any efferveſcence, though it had been precipitated by carbonated alkali; which ſhews, that this earth has no affinity with carbonic acid. The ſulphuric acid took up a large quantity of it. I continued adding this earth to the acid, until the laſt portion gave the ſolution an opaline appearance; but this again diſappeared on the addition of a ſlight quantity of ſulphuric acid, ſo that the ſolution then became clear. After cooling, it congealed into a milk-white, pulpy ſubſtance. For this reaſon I again added a little ſulphuric acid, which, aſſiſted by a low heat, rendered the ſolution again limpid, ſo that it no longer coagulated in the cold. I then left it ſtanding at reſt in a low temperature, and after ſome days I found the greateſt part of it ſhot into ſmall, detached, and clear cryſtalline groups, in radii of a flattened quadrilateral columnar form, diverging from a common centre, and terminating in ſharp points. Their taſte was but little ſour, and left on the tongue a ſlight aſtringency. When thrown into water, they ſoon and eaſily diſſolved, at the ſame time that they loſt their limpidity and became turbid. The remainder of the ſolution ſtill afforded ſome cryſtals of a fine granular form; and the laſt portion thickened into an irregularly ſhaped maſs.

f) Diſtilled vinegar, concentrated to a fourth part of its bulk by freezing, diſſolved the earth with equal readineſs, receiving from it the peculiar taſte already mentioned. This acetic ſolution dried by heat into a pulverulent reſidue, deliqueſcing in the air.

g) I likewiſe boiled a portion of the jargonic earth with a lye of concentrated and cauſtic lixivium of pot-aſh, previouſly heated to boiling. The earth merely ſubſided in it in a looſe, flocculent form, without being diſſolved.

h) It is, then, manifeſt, from the foregoing experiments, that the *Jargonia*, or jargonic earth, is entirely different from the aluminous. That it is equally diſtinct from the magneſian earth, has already been proved by the total abſence of all magneſian taſte in the ſulphuric ſolution,

tion, as well as by its incapability of abſorbing carbonic acid. However, that no circumſtance might be left unexplored in this examination, I re-diſſolved in ſulphuric acid the portion that yet remained; and having ſaturated with carbonat of lime the ſolution heated to boiling, I filtered the fluid from it after cooling. But neither the taſte, nor any other re-agents, could diſcover the ſmalleſt ſign of magneſia.

i) When this earth was tried with the blow-pipe upon charcoal, the phoſphoric ſalt proved unable to diſſolve any part of it, although its action was long continued; for the earth remained in the clear globule of that ſalt without any alteration. Nor was it found in any way attacked, when fuſed with ſoda in the ſmall ſilver-ſpoon. However, it diſſolved by degrees, completely, and without bubbling, in glaſs of borax; and the bead, thus produced, continued perfectly clear and colourleſs.

From the reſult of theſe experiments concerning the properties and relations of the earth extracted from the jargon, I think myſelf juſtified in conſidering it as a *new, diſtinct, ſimple earth*, before unknown; and at preſent I give it the name of *Zircon-earth* (*Terra Circonia*[*]), until it may, perhaps, be found in other ſpecies of ſtones, or poſſeſſed of other properties, that may give riſe to a more appropriate denomination.

In the mean time, I wiſh that the above facts may excite that attention which I think they deſerve: in order to induce one or more eminent chemical analyſts to repeat theſe reſearches, whereby the reſults of my own may be either confirmed or corrected.

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[*] In this country JARGONIA. Tranſl.

The proportion of the ingredients, conſtituting the jargon, is yet left to be determined. But it is obvious, that, whenever new conſtituent parts are diſcovered, the nature of which is as yet entirely unknown, and which do not admit of being treated by the methods hitherto practiſed, the determination of their proportions cannot be brought to that high degree of accuracy, which may be expected when the Chemiſt purſues a beaten path, and cannot want a chemical knowledge of the conſtituent parts which he meets with in the ſubject under his examination.

Hence, as from the *two hundred* grains of the jargon, ſubjected to this analyſis, I obtained

Silex . . B. *l*) . . .	58 grs.	61 grs.
n) . . .	3	
Oxyd of iron . *o*) . . .	½	1
C. *c*) . . .	½	
Remainder of undecompoſed *jargon* . B. *q*)		5
The quantity of this newly diſcovered JARGONIA may be eſtimated at		133
		200

And ſuppoſing that theſe remaining undecompoſed five grains contain the ſame proportion of conſtituent parts, we may eſtimate the ingredients in 100 parts of the jargon to be the following:

Silex

Silex	31,50
Oxyd of iron	0,50
Jargonia	68
	100

SECOND SECTION.

Since repeated experience has ſhewn me the powerful influence which the cauſtic alkali, when employed in the liquid ſtate, exerts in promoting a more complete decompoſition of the harder ſpecies of ſtones, I could not avoid ſubjecting the jargon likewiſe to this method of treatment. But to avoid ſuperfluous prolixity in this eſſay, I ſhall confine the circumſtantial detail of theſe new experiments to that analytical proceſs only, which I have found the moſt convenient.

A.

a) *One hundred* grains of ſelected jargons, previouſly comminuted in the ſteel-mortar, were ground with water to a moſt ſubtle powder, in the triturating diſh made of flint. When dried and ignited, they were found to have acquired *one half grain* of additional weight.

b) The powder of theſe ſtones was next ſtrongly digeſted in a menſtruum, compounded of 1½ ounce of muriatic acid, and half an ounce of the nitric. Cauſtic ammoniac, poured into the filtered bright-yellow fluid, produced a yellowiſh-white precipitation, weighing two grains after drying. The iron, which this precipitate contained, was re-diſſolved in moderately ſtrong muriatic acid, poured upon it in the cold; another part of it remained undiſſolved, and was ſeparated by filtration. The ferruginous contents of this laſt yellowiſh ſolution were again thrown down, in the form of brown, flocculent particles, by means of cauſtic ammoniac; after which they were collected and ignited upon charcoal. The precipitate appeared then in black, ſhining grains, which obeyed the magnet, and weighed ½ grain.

That portion which would not again diſſolve, and which ſtill preſerved its former yellowiſh-white hue, I likewiſe heated to redneſs, upon a piece of charcoal. By this management it acquired a faint, dark-brown colour at the firſt moment of ignition:—a phenomenon which does not uſually take place, except in the white oxyd of mangane{ſ}e. This portion weighed ¾ of a grain.

c) Upon the pulverized jargon, after treatment with acids, and adding the above-mentioned reſiduum of ¾ of a grain (*b*), I poured two ounces and a half of a cauſtic lye, in which the ſaline part made half the weight. The whole was then inſpiſſated in a ſilver-crucible to dryneſs, and moderately ignited for two hours; by which treatment the maſs preſerved a pap-like conſiſtence. When refrigerated, I ſoftened the indurated, grey-white maſs with water. The powder of the ſtone, thus ſeparated from the alkaline lye, when waſhed and dried in a low-heat, now reſembled elutriated chalk, and weighed 128 grains.

d) I then ſaturated the clear alkaline lixivium (*c*) with ſulphuric acid. By this it was not rendered turbid; but only after it had been evaporated to dryneſs, and the ſaline maſs again ſoftened with water, there appeared *ſiliceous earth*, amounting to three grains after ignition.

e) The above jargonic powder (*c*), being now prepared for ſolution in acids, I firſt affuſed upon it eight times its weight of water; and upon this mixture, which had aſſumed a milky appearance, I poured a ſufficient quantity of dilute ſulphuric acid. In this menſtruum, aſſiſted by heat, the whole of the powder (a few impurities excepted), diſſolved into a limpid, colourleſs liquor. After cooling, there ſettled around the ſides and bottom of the glaſs-veſſel an irregular cruſt, conſiſting of white cryſtalline grains; which again diſſolved upon affuſing more water of a warm temperature. This being done, the colourleſs ſolution was evaporated with a low heat. At the beginning of the proceſs it remained clear, but afterwards it coagulated into an uniform, pellucid jelly.

f) When this gelatinous coagulum had again been digeſted with a large quantity of water, it diſſolved into the form of tranſparent, viſcid grains; which, collected on the filter, and deſiccated, reſembled glaſſy ſand. Theſe being expoſed to a red heat, with four parts of mild vegetable alkali, and the maſs re-diſſolved in water, left behind 3 grains of earth. Sulphuric acid precipitated the *ſiliceous earth*, which was diſſolved in the alkaline ſolution, in its uſual ſlimy form. Its quantity amounted, after ignition, to 24 grains.

g) After thoſe three grains of earth (*f*), had been rediſſolved in ſulphuric acid, and, along with their ſolvent, added to the remainder of the foregoing ſolution, I precipitated the *jargonic earth* contained in that fluid, by means of a boiling lye of carbonated pot-aſh. The precipitated earth, edulcorated and dried in the air, was of a moderately looſe coheſion, of a white colour, a little inclining to that of fleſh, and weighed 122 grains. One fourth part of it, when ignited, amounted to 17½ grains; which gives 69 for the whole.

Therefore, the conſtituent parts of the *jargons*, analyſed, are, *in one hundred*,

Jargonic earth	g)		69,
Silex	d)	3	
	f)	24	
		27	
From which ſubtracted	a)	½	
		26½	26,50
Oxyd of iron	b)		0,50
			96
		Loſs	4
			100

B.

I ſhall farther mention ſome of my other analytical proceſſes, repeated on that ſubject under circumſtances ſomewhat diverſified, and alſo the obſervations which have occurred to me concerning the chemical habitudes, or relations of jargonic earth.

a) Both the accurate diſcovery of the proportion of the ſiliceous earth, and its thorough ſeparation from the earth of jargon, are rendered highly difficult by their intimate union, as well as by their reciprocal ſolution of each other. This end I have attained, in the ſureſt way, by the method juſt now deſcribed: and for this reaſon I recommend this as the beſt among ſeveral that I have attempted. However, there ſeems to obtain ſome little difference in the proportion of the ſiliceous earth, depending on the nature of the ſeveral varieties of the jargon; which is likewiſe made probable by the ſmall differences in the ſpecific weight of various ſpecimens of this ſtone.

b) If, upon the maſs obtained by ſoftening the jargon with water, after its ignition with cauſtic alkali, muriatic or ſulphuric acid be immediately poured, to a ſlight degree of ſuper-ſaturation, the whole is directly diſſolved, clearly, and without reſidue. The earth precipitated by means of alkali from this ſolution, hardens, during deſiccation in warmth, into tranſparent, vitreous, heavy, ſolid, and brittle lumps; which, in the moment they are removed from the heat, fly into ſmall pieces, with vehemence and noiſe; ſome of which, if not incloſed in paper, are often thrown to a great diſtance. The higher the temperature in which the earth has been dried, the greater is the reſidue left behind undiſſolved, when again conveyed into acid menſtrua, for ſolution.

c) It does not ſeem that the boiling of rough, pulverized jargon, in acids, is fully competent to extract completely their proportion of iron. If, therefore, the prepared earth of jargon be again diſſolved in an acid, and combined with pruſſiat of pot-aſh, the ferruginous remainder will appear in the form of a precipitate, ſometimes of a Pruſſian-blue; at others, of a bright mountain-blue. But this precipitate is unable to indicate the true quantity of iron which it exhibits; for it conſiſts not only of a ſmall portion of oxyded iron, but alſo of a much greater part of jargonic earth, thrown down along with it, which afterwards reſiſts a farther ſeparation. It is, from the preſence of this earth, united with the precipitated iron, that the above precipitate acquires a pale, reddiſh colour after ignition, and is hardly attracted by the magnet.

Conſequently, not ſo much with the view of aſcertaining the proportion of the conſtituent parts, as to produce the *jargonia* abſolutely free from iron, it is adviſeable to re-diſſolve the earth firſt obtained, in an acid, and to ſeparate that ſmall remainder of iron by pruſſiated alkali. The iron being thus got rid of, the earth of circon, now perfectly pure, ſhould be at laſt precipitated by means of an alkali, in a heat of ebullition.

d) To obtain the circon-earth in a ſtate of eaſy ſolution in acids, it is neceſſary that, after precipitation and waſhing, it ſhould be dried in a gentle heat only. Strongly ignited earth of jargon will not diſſolve in acids, unleſs again previouſly prepared for that proceſs by igniting it along with cauſtic alkali.

e) When the jargonia is to be precipitated from acid ſolutions, by means of carbonated pot-aſh, the point of ſaturation ſhould not be exceeded; ſince, otherwiſe, in proportion to the exceſs of alkali added, it will, either in part or wholly, be re-diſſolved in the fluid, and can only then be made to re-appear by adding freſh acid to the ſuperfluous alkali. However, this earth is not re-diſſolved, if the precipitation is performed by cauſtic vegetable alkali, though the fluid ſhould happen to be ſuper-ſaturated with the ſalt.

f) Of all the acid ſolutions of jargonic earth, that which is prepared with muriatic acid has the greateſt tendency to cryſtallize. If committed to ſpontaneous evaporation, the *muriat of jargonia* ſhoots into very ſlender, acicular cryſtals, radiated in a diverging direction, which continue dry on expoſure to air.

g) The jargonia is not at all diſpoſed to vitrifaction; which is proved by the following experiment. A glaſs frit, compoſed of 60 grains of jargonia, and 40 grains of mild alkali prepared from tartar, was expoſed, in a crucible made of clay, to an intenſe and long continued fire. But by this proceſs not only was no union of theſe two ſubſtances effected, but they even entirely ſeparated. The alkali fixed itſelf on the ſides of the veſſel in indurated grains; and in the middle the jargonic earth lay by itſelf, in the form of a coarſe, harſh, and looſely conglutinated powder, of a yellowiſh-white colour.

XIII.

CHEMICAL EXAMINATION

OF

HYACINTH.

ON giving the firſt information of the new ſimple earth diſcovered in the Jargon of Ceylon, I declared, at the ſame time, my earneſt deſire of ſeeing this diſcovery farther purſued, and confirmed by probatory reſearches of able chemiſts. That wiſh, however, remained unfulfilled, with the exception of ſome few experiments made by *Gmelin*. It is probable that the few opportunities, which have hitherto occurred of obtaining jargon pebbles in a ſufficient quantity, have prevented chemiſts from inſtituting a particular inquiry into their nature. They will, therefore, it is hoped, find pleaſure in hearing, that the ſame earth is likewiſe contained in another gem, the *Hyacinth*, which may be eaſily obtained, and in ſufficient quantity. This information will, perhaps, cauſe ſurprize, ſince the analyſis of the Hyacinth, publiſhed by *Torb. Bergman*, appears to have been long ſince confirmed by its general reception. According to this, the Hyacinth is ſuppoſed to conſiſt of,

40 . . .	*Argil,*
25 . . .	*Silex,*
20 . . .	*Lime, and*
13 . . .	*Oxyd of iron.*

Therefore, to obviate all doubts that may ariſe concerning the correctneſs of my preſent analyſis, I declare before hand, that it is not merely the reſult of one ſingle and ſuperficial decompoſition of the Hyacinth, but of ſeveral analyſes of that gem, performed at different intervals of time, and in every reſpect complete.

The native country of the Hyacinth, which was the ſubject of the following experiments, is *Ceylon.*—Whether thoſe ſpecies of ſtones, which in European countries, in *Bohemia, Italy,* and *France,* for inſtance, are indicated by this denomination, are true Hyacinths, I have not, as yet, been able to convince myſelf by any ſatisfactory proof.

I have found the ſpecific gravity of the genuine Hyacinth for the moſt part to agree with that of the Jargon; that is, according to its varieties, from 4,545 to 4,620.

The detail of the experiments, which, with ſome variations, I repeated with the Hyacinth, may be the leſs circumſtantial, ſince, in eſſential points, the ſame holds good with reſpect to this gem, as what I have ſtated in the ſecond ſection of the preceding eſſay to belong to the Jargon, its analyſis and its conſtituent parts.

a) *One hundred grains* of Hyacinth received, by levigation in the flint-mortar, an increaſe of weight of ½ grain; which ſhews that its hardneſs is not materially different from that of the jargon *b*) This pulverized hyacinth, digeſted with two ounces of nitro-muriatic acid, yielded, upon ſaturating the ſolution with pot-aſh, a light-brown precipitate, of 3½ grains, when dried. Ammoniac, added to it, diſſolved nothing; and it remained colourleſs. After the precipitate had been again ſeparated from the volatile alkali, I put it into muriatic acid, which diſſolved its ferruginous contents, leaving a white earth behind, which, when ignited, weighed 1½ grain. The portion of *iron*, precipitated by cauſtic ammoniac from the muriatic ſolution, weighed ½ grain, when ignited, and became black and reſplendent. I fuſed it with a neutral phoſphat, upon charcoal, in order to find whether it contained mangaveſe; but no trace of it was perceptible.

c) The above 1½ grains of earth *(b)* were now added again to the hyacinth, after treatment with acids. The ſtone was then ſubjected to red-heat, with ſix times its quantity of cauſtic alkali, in the manner explained in the eſſay on the jargon of Ceylon; the ignited maſs was again liquefied with water; and the earth remaining after this proceſs weighed 123 grains, when collected, edulcorated, and dried.

d) The alkaline lixivium was then ſaturated with muriatic acid, and evaporated. At firſt it continued clear; but towards the end *ſiliceous earth* ſeparated, the quantity of which, after ignition, amounted to 6 grains.

e) Upon thoſe 123 grains, previouſly well waſhed with water, I poured a ſufficient quantity of muriatic acid; which, with the aſſiſtance of heat, diſſolved nearly the whole, a trifling reſidue excepted. This muriatic ſolution, evaporated in a moderate heat to a ſixth or eighth part, loſt its fluidity, and formed a limpid gelatinous coagulum.

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It was then covered with water, and expoſed, with repeated agitation, to a digeſting heat. By this management, the *ſiliceous earth* ſeparated in ſlimy, intumeſced grains, and weighed, after ignition, 23½ grains.

f) The ſolution, thus freed from its ſilex, was now ſaturated with a boiling lye of mild alkali; and the precipitate was waſhed and dried in the air. This laſt weighed 114 grains, proving, upon every trial, to be *jargonic earth.* A fourth part of it, heated to redneſs, weighed 16½ grains; which make the whole amount to 66 grains.

g) The above 6 grains *(d)*, with the 23½ grains *(e)* in the whole 29½ grains of ſiliceous earth, were ignited with a quadruple weight of vegetable alkali. When this maſs had been again ſoftened with water, it left a reſidue, which I extracted by muriatic acid. From this muriatic ſolution, alſo, when ſaturated with pot-aſh, jargonic earth fell down, weighing 4 grains after ignition. Hence, ſubtracting theſe, the quantity of ſiliceous earth is reduced to 25½ grains.

One hundred parts of *hyacinth*, therefore, have given

Jargonia	*f*)	66	70
	g)	4	
Silex	*g*)	25½	
Subtract	*a*)	½	
		25	25
Oxyd of iron	*b*)		0,50
			95,50
		Loſs	4,50
			100

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What I have already mentioned, when treating of the jargon of Ceylon, both with reſpect to the variation in the proportion of the ſilex, and the ſmall quantity of iron ſtill remaining, which may be ſeparated by means of Pruſſian alkali, applies likewiſe to the hyacinth.

Hence, the *jargon* of Ceylon, and the *hyacinth*, ſhould, in future, be ranked in the ſeries of natural bodies as *two ſpecies*; or, if it be preferred, as *two genera*, under *one* peculiar and diſtinct *order of ſtones*. But which of theſe two is entitled to preference, in giving its name to the genus?—The jargon has, indeed, already obtained that diſtinction; but ought it not to be transferred to the hyacinth, being a gem much older, longer known, and more eſteemed?—If ſo, the denomination *hyacinth-earth* ſhould then be adopted, and ſubſtituted to that of *circonia*, or *jargonia*.

XIV.

CHEMICAL EXAMINATION

OF THE SUPPOSED

HUNGARIAN RED SHÖRL.

THE foſſil, found at *Böinik*[*], in Hungary, and called *red Shörl*, is there dug up from a bed of quarz, ſtratified with ſhiſtoſe mica. Its colour is a pale browniſh-red. Its figure is a column ſtrongly furrowed, or channelled, lengthways, which, in my ſpecimens, exhibits a rectangular parallelopipedon. The larger ſpecimens which I poſſeſs are ½ inch thick; but theſe ſhörls are commonly thinner, and form only needle-ſhaped cryſtals, the external ſurfaces of which are ſtriated, and, as well as thoſe of the fragments, ſtrongly ſhining. Their croſs fracture is foliated; the longitudinal fracture of a medium between the foliated and uneven, and in ſome parts of the minute conchoidal. The ſplinters of this foſſil, and thin edges, are tranſparent, like the light-red ſilver-ore, which, in general, it very much re-

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[*] *Born* mentions *Rhoniz* as the place where it is found. See his *Catalogue Meth. et Rais. de la Collect. d. Foſſil.* Tom. i. p. 168.

reſembles when in fragments. It breaks into ſmall acute-angular pieces, which, however, ſhew a very great hardneſs on trituration; and the colour of the powder is between the orange and brick-red. Its ſpecific gravity I have found to be 4,180.

It was undoubtedly the oblong form, together with the ſtriated, fluted ſurface of its cryſtals, which occaſioned this foſſil to be claſſed under the tribe of ſhörl: whereas other mineralogiſts think themſelves entitled, from its colour and fracture, to reckon it a garnet.

But it will be made evident by the reſults of the following analyſis, that this mineral body belongs neither to the one nor to the other of thoſe ſpecies of ſtones, nor at all to the claſs compriſing the genera of earths and ſtones. On the contrary, it will appear that it conſiſts of a *peculiar, diſtinct, metallic ſubſtance**.

A.

a) I expoſed a piece of this mineral, in a *crucible made of clay*, to the heat of the porcelain furnace. By this it ſuffered no change as to figure and luſtre; but the colour paſſed into a deep brown-red.

b) Another ſpecimen, that was ſubjected to a porcelain heat in a *charcoal-crucible*, burſt into angular grains; while its colour changed to a faint light-brown, and ſcarcely any of its original luſtre remained.

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* For the quantity of this rather ſcarce foſſil, requiſite to this analyſis, I am indebted to the kindneſs of *Count Würben*, of Vienna.

c) When fuſed with an alkaline phoſphat, upon charcoal, before the blow-pipe, no ſolution enſues. The globule acquires a pale reddiſh-grey, and turns opake. A gentle preſſure makes it fall aſunder, in the form of ſand.

d) Melted borat of ſoda (borax) diſſolves it, uniting with it to a clear vitreous bead of an hyacinthine red.

e) If the powder of this foſſil be fuſed in the ſilver ſpoon with *ſoda*, it gradually diſſolves, and the globule becomes untranſparent, and of a reddiſh white colour, after cooling.

B.

In order to examine the agency of acids on this mineral, when finely pulverized, I inſerted ſeveral portions of it in *four* ſeparate phials, and poured upon one *ſulphuric*, upon the other *nitric*, upon the third *muriatic*, and upon the laſt *nitro-muriatic* acid; ſubjecting them all to long digeſtion in a ſtrong heat. No action enſued in either; for the foſſil was again taken out of each acid without any alteration.

C.

Having blended *one hundred grains* of the foſſil, finely levigated with four times its weight of cauſtic pot-aſh, I expoſed it to a red-heat for one hour. When removed from the fire, I ſoftened it by water, ſuper-ſaturated with muriatic acid, and ſubjected it to digeſtion. There ſeemed

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but little of it diſſolved, and the undiſſolved part lay at the bottom of the veſſel, as a white, tenacious, and heavy earth. When the mixture was thrown upon the filter, in order to ſeparate the fluid, it paſſed through the pores of the paper in the form of milk. For this reaſon, I put the whole again together into one maſs, diluting it with a greater quantity of water; and the earth having ſubſided after 24 hours, the water was decanted, and the ſediment dried in a warm temperature. By this management it again acquired a reddiſh colour.

This ſeemed to indicate that the coheſion of this ſhörl was not yet perfectly looſened. I therefore ignited it once more with 200 grains of the cauſtic ſalt, and again digeſted, with muriatic acid, the maſs previouſly ſoftened. Even in this caſe the mixture reſembled milk, and continued ſeveral days in this ſtate, without becoming clear. I diluted it then with more water, and made it boil: upon which the earth ſeparated in detached, flocculent particles, which then admitted of being collected on the filter. But they adhered to it very firmly and clammily; which, upon exſiccation, rendered its ſeparation difficult.

I inſtituted ſeveral preliminary experiments with that portion which could be collected; by which I learnt, that, in this inſtance, I was engaged with a peculiar *metallic oxyd.*

D.

I repeated the decompoſition of the foſſil with ſuch a variation of the proceſs, as to avoid the difficulty in ſeparating and collecting the precipitate, which took place in the preceding attempts.

Two hundred grains of the foſſil, finely pulverized, and mingled with five times their quantity of carbonated alkali, were ignited in a porcelain-pot. The mixture entered into a thin fuſion; but when poured out, it coagulated to a greyiſh-white, denſe maſs of acicular cryſtals, at the upper ſurface, and of a fibrous fracture. This I triturated and liquefied in boiling water. A white precipitate ſoon ſubſided, from which the ſupernatant liquor was filtered off, and ſaturated with muriatic acid. By this management, a white, ſlimy earth fell down, that weighed eight grains after drying, and conſiſted of a mixture of argillaceous and ſiliceous earths.

The reſiduum, waſhed, and deſiccated in a gentle heat, appeared as a white looſe earth, and weighed 328 grains.

E.

This white earth was ſubjected to a number of experiments; the reſults of which were, as follows.

1. *Its relations to acids.*

a) It ſoon diſſolved in *dilute ſulphuric acid*, and afforded a clear ſolution, which, when expoſed to the air, evaporated, leaving a white, turbid, paſte-like ſubſtance behind it.

b) *Nitric acid* likewiſe formed with it a limpid ſolution. By ſpontaneous evaporation, this acquired an oily conſiſtence, and depoſited minute tranſparent cryſtals, the primitive figure of which was an oblong rhomb, and ſeemed to change into an hexahedral plate, or table, by the truncation of its two oppoſite acute angular ends.

c) When the ſolution of this earth in *muriatic acid* was left to evaporate of itſelf, it thickened to a bright-yellow, clear, gelatinous ſubſtance, beneath which there ſhot a quantity of very ſmall, clear, cryſtalline grains, of a cubical form.

In theſe acid ſolutions there remained between five and ſix parts of *ſiliceous earth* in the hundred. However, a quantity of *ſiliceous earth*, to appearance ſtill more condera-ble, was yet left behind, in combination with the white earth, and entered with it into the ſolutions. It is by this circumſtance that theſe ſolutions are reduced to a gelatinous coagulum, and that a more regular cryſtallization is impeded.

2. *Relations of theſe ſolutions to the precipitating media.*

a) *Carbonat of pot-aſh* precipitates the diſſolved earth in a white, light, flocculent form.

b) *Cauſtic ammoniac* produces the ſame effect.

c) *Pruſſiat of pot-aſh* affords a large precipitate, mixed of graſs-green and brown.

d) *Tincture of galls*, or *gallic acid*, throws down a brown-red precipitate, of very conſiderable bulk. If the ſolution has not been previouſly diluted with much water, it congeals like blood. Alkalis ſeparate nothing from the decanted fluid. The precipitate, when collected, waſhed, and dried, has the appearance of *Kerme's mineral* (red fulphurated oxyd of antimony). When I expoſed 15 grains of this powder to a weak heat, upon coals, in a ſmall crucible, it immediately glimmered, and turned white. After this degree of ignition, it was found to weigh 6 grains.

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e) When combined with *acid of arſenic*, a white precipitate enſues.

f) The ſame is occaſioned by *phoſphoric acid.*

g) *Acid of tartar* produces a white precipitate, but which ſoon entirely re-diſſolves.

h) The ſame takes place upon the addition of *oxalic acid.*

i) A ſmall *ſtick of tin* was immerſed in a phial, full of a muriatic ſolution of the foſſil, and provided with a ſtopper. After ſome minutes a faint roſe-colour ſhewed itſelf around the ſtick of *tin*, paſſing, at laſt, into a beautiful amethyſtine red.

k) Another phial, capable of being cloſed with a ſtopper, was filled with this muriatic ſolution, but diluted with ſix times the quantity of water; and into this I put a ſmall ſtick of zinc. The ſolution at firſt changed to a violet, but afterwards to a deep indigo-blue. When placed in a warm temperature, in an uncovered diſh, the ſolution gradually loſt its colour, and depoſited a white, bulky precipitate; which, when ſeparated by filtration, and again diſſolved in muriatic acid, retained the ſame properties as the earth did before the ſolution.

l) But the muriatic ſolution, when combined with *Hahneman's acidulous liquor, impregnated with ſulphureous gas* *, remained unaltered.

m) However, *Beguin's ſulphuret of ammoniac*, added to that mixture, gave it a dirty, green colour, and produced a blueiſh-green precipitate. If the white earth, in the *dry*

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* Hahneman's *Wine Proof.* See *Gren's* Principles of Chemiſtry, vol. ii. page 253. *note.*—Tranſl.

ſtate, be covered with this fluid, it is immediately tinged of a browniſh-green.

3. *Habitudes of the above-mentioned earth in the dry way.*

a) *Fifty grains* of the white earth, mentioned above, when ignited in a crucible, were afterwards found to weigh 38 grains. As long as it continued warm, it exhibited the yellow colour of ſulphur; which, however, diſappeared upon cooling. This earth, after ignition, is no longer acted on by acid menſtrua.

b) But if the earth be heated to redneſs upon charcoal, it firſt becomes reddiſh, and then of a ſlate-blue. By this treatment it alſo fuſes into an ill-ſhaped globule, which, after refrigeration, preſents a finely radiated ſurface. However, this melting is effected, perhaps, only by a ſmall portion of alkali, which ſtill adheres to the earth.

c) The ſame earth, when fuſed upon charcoal, with a neutral phoſphat and *borax*, or with *ſoda*, in the ſmall ſpoon, yields the ſame reſults as does the rough foſſil, when treated with theſe fluxes. (A. c, d. e).

d). This white earth, alſo, mixed and conveyed with a proper *enamel-flux*, upon porcelain, and baked, produced a pure ſtraw-yellow colour, of a good body. This colour was likewiſe obtained by the raw mineral.

e) At laſt I attempted to reduce it to the reguline ſtate. For this purpoſe I blended 60 grains of the white earth, ignited, with 30 grains of pulverized *colophony* (the reſidue after the diſtillation of the etherial oil from turpentine), and cauſed this laſt to burn away by means of a gentle fire. No ſooner had the flame ceaſed, than the earth appeared again as white as before. It was next divided into two parts. The one half of it was mingled with 20 grains of pulverized white glaſs and 10 grains of calcined borax, and incloſed together in a crucible made of charcoal. The other half was introduced—alone—into the cavity of the charcoal-crucible, covered only with a mixture of glaſs and borax. Both crucibles, well ſecured, were then put into the porcelain-furnace; and both afforded the ſame product; which conſiſted of an irregularly fuſed ſlag, or ſcoria, browniſh at top, light-blueiſh-green below, and of a finely poroſe fracture, with ſome detached large air-holes, the interior ſides of which ſeemed to be confuſedly ſtriated.

This foſſil, therefore, belongs to thoſe *metallic ſubſtances* which appear to be incapable of being exhibited in the ſtate of a fuſed metallic bead.

F.

The ſum of theſe reſults furniſhes ſeveral arguments, upon the ſtrength of which I do not ſcruple to conſider the *red ſhörl*, as it has been hitherto called, of *Boinik in Hungary*, as a natural *metallic oxyd.* The phenomena, upon which I ground my concluſion, are: That the white earth, ſubjected to ignition, becomes yellow, reddiſh, and, in contact with charcoal, blueiſh; that it produces a yellow enamel colour; that it is precipitated from its ſolutions in acids, by Pruſſian alkali, gallic acid, and alkaline ſulphuret; that, when treated in the humid way with tin and zinc, it is recovered in dark flakes, the ſolution then acquiring a red and blue colour; and, laſtly, that it ſhews a very ſtrong tendency to combine with oxygen. It is on account of this laſt property, that the crude foſſil, as being fully ſatu-

rated

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rated with that acidifying principle, is inſoluble in acids, and is rendered capable of ſolution only when, by ignition with an alkali, it is deprived of a part of its oxygen. For this reaſon, likewiſe, when I ignited the rough foſſil, in a ſubſequent analytical experiment, with only two parts of vegetable alkali, the earth obtained did not prove ſo white and looſe as that fuſed with five or ſix parts. It alſo diſſolved but imperfectly, in muriatic acid, and not at all in the ſulphuric and nitric.

To theſe facts muſt be added the phenomenon, that the muriatic ſolution of that ſubſtance became changed into a blue tincture by zinc; but when decanted, and expoſed to open air, in a warm place, it again loſt its colour, by imbibing oxygen, and depoſited a white earth.

Another phenomenon, probably the conſequence of ſuper-ſaturation with oxygen, took place when I endeavoured to promote the cryſtallization of a complete muriatic ſolution, by evaporating it in a ſand-bath. This was, that the liquor, which had before been perfectly clear, acquired a turbidneſs and reſemblance to milk, by the heat: nor could it any more be rendered a limpid ſolution by the freſh addition of acid.

It is ſufficiently ſhewn, by ſeveral of its properties, that this metallic ſubſtance does not belong to any of thoſe at preſent known, but rather deſerves to be reputed a new, peculiar genus of metals. Among theſe, the copious *brown-red precipitate*, produced by the gallic acid, furniſhes an eaſy teſt and ſpecific means of diſtinguiſhing it from other metals.

We are yet to give this new metallic ſubſtance an appropriate name.

Whenever no name can be found for a new foſſil which indicates its peculiar and characteriſtic properties (in which ſituation I find myſelf at preſent), I think it beſt to chooſe ſuch a denomination as means nothing of itſelf, and thus can give no riſe to any erroneous ideas. In conſequence of this, as I did in the caſe of the Uranium, I ſhall borrow the name for this metallic ſubſtance from mythology, and in particular from the *Titans*, the firſt ſons of the earth. I therefore call this new metallic genus TITANIUM*; of which this *Titanium*, mineralized by oxygen, or *oxyd of Titanium*, is, indeed the *firſt*, *but perhaps not the only ſpecies*, as is made probable by the following eſſay.

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* The metal called *Menachanite*, by *Kirwan*, Mineralogy, vol. II. part iv. chap. 21, is the ſame, or analogous to Klaproth's Titanium. See *Gren's Principles of Modern Chemiſtry*, 1800. Lond. 8vo. vol. ii. page 425.—Tranſl.

XV.

CHEMICAL EXAMINATION

OF

A NEW FOSSIL, from the Diſtrict of Paſſau.

AMONG the various and hitherto unknown cryſtallizations of ſome foſſils, which profeſſor *Hunger* has diſcovered in the biſhopric of Paſſau, and whoſe external characters he has deſcribed[*], there is one particularly remarkable, as even its conſtituent parts are not yet known.

The cryſtals of that foſſil are ſmall quadrangular rhombic columns, of a reddiſh, greyiſh, and blackiſh-brown colour. Their ſize varies from $\frac{1}{48}$ to $\frac{1}{4}$ of an inch. Their lateral facets are joined alternately, under angles from 135 o 45 degrees. Both their ends form very ſharp angles; and the inclining ſides iſſue from the obtuſe lateral edge. Their ſurface is ſmooth and reſplendent. Their croſs-fracture is dim, but their longitudinal fracture exhibits a middling luſtre. The ſmalleſt cryſtals of that mineral, and ſometimes its edges, are tranſparent; but it is often totally opake. Though its cryſtals are brittle, and eaſily friable, yet they ſhew a conſiderable hardneſs when grinding, and then afford a whitiſh-grey powder.

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[*] *Beobachtungen und Entdeckungen aus der Naturkunde.* 5ter. Band, 2tes St. Berlin, 1794.

It is met with in ſeveral places in the neighbourhood of *Paſſau*, and alſo, though ſeldom, in the *Innviertel*, in Bavaria. Thoſe cryſtals almoſt always occur diſperſed in a ſpecies of coarſely-grained ſtony matter, the predominant part of which conſiſts of a greyiſh, or greeniſh-white felſpar, mingled with hornblende, quarz, mica, ſemi-indurated ſteatites, of which ſometimes all together are united with it; and, at other times, only one or two*.

A.

a) The ſpecific gravity of this foſſil is 3,510.

b) Its cryſtals, when ignited upon charcoal, before the blow-pipe, ſuffered no remarkable change, except that here and there very minute bubbles were produced on their ſurface.

c) Expoſed in a *crucible made of clay*, to the moſt intenſe heat of the porcelain furnace, they likewiſe continued without farther alteration; but in the *charcoal crucible* they concreted into a ſcoria, half-fuſed, black, opake, ſomewhat porous, and of a moderate luſtre.

d) On being treated in the humid way with muriatic acid, and repeatedly digeſted with it, one third part of their weight was diſſolved. This ſolution had a ſtraw-yellow colour; and the addition of cauſtic ammoniac, in exceſs, afforded a precipitate, whoſe appearance and conſiſtence reſembled paſte made of ſtarch; but which, when dried and ground, exhibited a looſe, yellowiſh powder. The remaining fluid contained, alſo, ſome *calcareous earth*, which I precipitated from it by carbonat of ſoda.

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* Profeſſor *Hunger* had the kindneſs to ſend me ſome of his cryſtals, which had been collected with great trouble, in quantity ſufficient for inveſtigating the conſtituent parts of this mineral.

What remained, after the extraction by means of the acid, I ſubjected to ignition, together with four times its weight of mild alkali, prepared from tartar. It was next ſaturated to exceſs, and digeſted with muriatic acid, and filtered. *Siliceous earth* was then left behind on the paper. Cauſtic ammoniac threw down from this ſolution a precipitate perfectly reſembling the foregoing; to which, therefore, it was added.

The external appearance of this precipitate led me to ſuſpect in it the preſence of aluminous earth, impregnated with iron. However, it was not found to be ſo upon farther examination: for, after I had again diſſolved it in muriatic acid, and once more precipitated it from this laſt ſolution, the cauſtic alkaline lye, with which the precipitate was digeſted after edulcoration (while yet in a pulpy ſtate), would diſſolve only a very trifling portion of it.

I then fuſed, with glaſs of borax, a ſmall portion of the precipitate, again waſhed and dried; and obtained a ſmall topaz-yellow glaſs-globule. Another portion, fuſed with phoſphoric ſalt, produced one of a pale amethyſtine colour.

Again; another ſmall portion of it, which was diſſolved in dilute ſulphuric acid, ſhewed no ſenſible taſte of alum, and dried to a whitiſh maſs, without ſhooting into cryſtals.

The

The remainder of that precipitate I re-diſſolved in muriatic acid, and treated the ſolution with the following teſts, or re-agents.

Pruſſian alkali produced a dark-green precipitate.

Gallic acid afforded a precipitate of a lively brown-red colour, but paſſing into a pale yellow-red, as it cooled.

A little ſtick of zinc was immerſed into that part of the ſolution which yet remained; and a ſubtle greeniſh-black ſlime was obſerved ſettling around it, at the ſame time that the ſolution itſelf aſſumed the colour of amethyſt. The fluid again loſt that colour after ſome days, and white, flocculent particles, mingled with the ſlime, fell down.

B.

Guided by theſe previous obſervations, I proceeded to the following new experiment.

a) *One hundred grains*, finely ground, were ſubjected, for one hour, to ignition, with a quadruple weight of cauſtic alkali. The maſs, ſoftened by water, yielded a weak graſs-green ſolution; but this colour diſappeared again, as ſoon as more water was added a-freſh. Upon digeſting it with muriatic acid, added to exceſs, and ſubſequent filtration, *ſiliceous earth* was left behind, which, when ignited, amounted to 12 grains.

b) The diſſolved part was next precipitated, by means of carbonated pot-aſh. Upon the dried precipitate, I added a new portion of muriatic acid, and a notable ſmell of oxygenated muriatic acid gas was emitted. During the di-

digeſtion, there again ſeparated ſome *ſiliceous earth*, the quantity of which, after ignition, amounted to 23 grains.

c) At this time, I combined the ſolution with cauſtic ammoniac. The yellowiſh-white precipitate, obtained thereby, weighed 62 grains, upon deſiccation. One *fourth* part of it, heated to redneſs, was found to weigh 8¼ grains; whence its whole quantity makes 33 grains.

d) To the remaining fluid, mild vegetable alkali has been added, at a boiling heat. It thereby yielded *calcareous earth*, to the amount of 33 grains, when ignited.

C.

Having, in this manner, diſcovered the proportion of the conſtituent parts, I next examined, a ſecond time, the precipitate obtained (B. c.).

a) When ignited alone upon charcoal, it turned browniſh-yellow, and, at laſt, blackiſh.

b) By fuſing it with *borax*, a tranſparent globule of an hyacinthine colour was produced.

c) *Phoſphoric ſalt* did not diſſolve it, but only divided it minutely. If any trace of manganeſe had remained in this precipitate, it would have manifeſted itſelf by a faint amethyſt-colour, with which it tinges phoſphoric glaſs.

d) The portion diſſolved in acids was thrown down by *tincture, or acid of galls*, of a lively, brown-red hue.

e) *Pruſſiat of pot-aſh* afforded with it a green precipitate, inclining to brown, and thereby reſembling ſap-green. This, however, when dried, appeared again with its original green colour. The liquor, ſeparated from it by filtration, was not altered by re-agents.

f) The addition of *ſulphuret of ammoniac*, prepared after *Beguin*'s manner, produced a flocculent precipitate, of a dark muddy-green.

g) *Phoſphoric acid*, as well as

h) *The acid of arſenic*, produced a white precipitate.

i) Laſtly, this precipitate, when combined with a proper quantity of enamel-flux (*glaſs-paſte*), and thus laid upon porcelain, and fuſed, gave to its ſurface a *yellow* colour, verging to brown.

Therefore, ſince theſe reſults not only indicate, in an unqueſtionable manner, the metallic nature of this conſtituent part, but, moreover, ſince its habitudes, upon the whole, very much correſpond with thoſe of the Titanium (the new metallic ſubſtance treated of in the laſt eſſay); and, finally, ſince the trifling varieties in the various phenomena ſeem to originate merely from accidental circumſtances, I do not heſitate to reckon this conſtituent part as an *oxyd of Titanium*.

And, in order that this foſſil itſelf may be diſtinguiſhed by a particular name, as a *diſtinct ſpecies*, the denomination *Titanite*, derivated from the above new metallic ſubſtance, does not ſeem to be altogether improper. Its conſtituent parts have been found to exiſt in it in the following proportions:

Silex	B. *a*) 12		
	b) 23	}	35
Lime	*d*)		33
Oxyd of Titanium	*c*)		33
Manganeſe, a ſlight trace.			
			101

Now, what place ought to be aſſigned, in the mineralogical ſyſtem, to this new foſſil? Since mineralogiſts are not yet agreed as to the principles, according to which the ſyſtem of mineralogy ſhould be arranged, thoſe who direct their principal regard to the *ſpecifical* conſtituent part, will readily claſs the *Titanite* as a *ſecond ſpecies* of the *Titanium genus*. Such, on the contrary, as inſiſt more ſtrictly on the predominant part, with regard to quantity, will, perhaps, decide for its inſertion under the head *ſiliceous genus*.

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XVI.

EXAMINATION

OF THE SUPPOSED

MOLYBDENOUS SILVER.

A FEW years ago a metallic foſſil was met with at *Deutſch-Pilſen*, in the *Comitatus Hontenſis*, in *Hungary*, which by *Born* has been introduced as a new ſpecies of ſilver-ores.—He gives the following deſcription of it*.

ARGENT MOLYBDIQUE.

Silver combined with ſulphurated Molybdena.

"*This combination or alloy of ſilver with ſulphurated* "*molybdena has been till now unknown. It is no where* "*found, except at* Deutſch-Pilſen *in* Hungary, *where it* "*was met with in inſulated kidney-form nodules* (rognons), "*from one to two inches in thickneſs, enveloped in a common* "*grey clay. Theſe nodules ſeparate in pretty large and* "*ſhining laminas, that admit of a new diviſion into ſmaller* "*lamellas, perfectly reſembling ſulphurated molybdena, and* "*ſtaining the paper with grey traces. By cupelling this* "*ſulphurated molybdena, there are obtained* 23 *marcs of ſil-* "*ver* (184 oz.), *from one centner.*"

As, from the peculiar ſcarcity of this mineral, few chemiſts only may have opportunity of examining it, I undertook this taſk the more readily: and I found by theſe reſearches, that it contains neither *ſilver*, nor *molybdena*, and that it conſiſts of *biſmuth, mineralized by ſulphur**.

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* See his *Catalogue de la Collection des Foſſiles de Mlle de Raab.* Tom. II. p. 419.

A.

A.

a) If this ore be tried *per ſe* upon charcoal, with the aſſiſtance of the blow-pipe, it runs into a globule, as ſoon as it comes in contact with the point of the flame. That globule may be gradually blown off by means of the bellows, in which caſe it gives out a metallic vapour, which in part ſettles on the coal, of a yellow colour. But if borax, or a neutral phoſphat, be added, it ſeparates from the melting ſaline pearl, and leaves the latter colourleſs behind it.

2) *Twenty-five* docimaſtic pounds of this ore[†] ſubjected to cupellation under the muffle, with four times their weight of lead, left behind them a globule of ſilver, only viſible by the microſcope; but this, undoubtedly, muſt have been furniſhed by the lead.

B.

a) Upon *fifty* grains of the triturated ore I poured moderately ſtrong nitric acid. It was immediately attacked and diſſolved by it, with extrication of red vapours; and the reſiduum conſiſted of 2½ grains of ſulphur.

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[*] That I may not be ſuſpected of having beſtowed my labour not upon the genuine *argent molybdique* of *Born*, I here declare, that the ſpecimen which I examined was a fragment of the very individual piece, of which Born has deſcribed the above external characters.

[†] About 24½ drachms *Troy-weight*. The German docimaſtic centner, or one drachm, is equal to 72 *French* grains of the former *poid de marc*, which correſpond to 59,0677 *Engliſh grains Troy*. Tranſl.

b) I afterwards diluted the ſolution with a large quantity of water; upon which the mixture inſtantaneouſly aſſumed the appearance of milk, and depoſited a fine, white, and heavy precipitate, conſiſting of pure *oxyd of biſmuth*.

c) The fluid ſeparated by filtration was mixed with muriat of ſoda. It continued at firſt perfectly clear, but gradually it was rendered ſomewhat milky; and at the bottom there collected a ſubtle, ponderous precipitate, the dazzling whiteneſs of which ſuffered not the leaſt change by the day's light, and was likewiſe merely *oxyd of biſmuth*. Had there exiſted in it any trace of muriated ſilver, however ſmall, it would have diſcovered itſelf by tarniſhing the white colour of that precipitate, on expoſure to the light of the day.

Conſequently, *one hundred* parts of this ore contain:

Biſmuth	95
Sulphur	5
	100

From this ſmall proportion of ſulphur, it ſeems that the biſmuth is but imperfectly mineralized; hence that ore nearly approaches to native biſmuth. And probably on this circumſtance depend its whiter colour, and brighter luſtre, which ſo much reſembles that of ſilver recently poliſhed; and by which it is diſtinguiſhed, in external character, from the ſulphurated biſmuth of *Riddarhyttan*, in *Weſtmanland*, which is more of a lead-grey colour.

XVII.

XVII.

EXAMINATION
OF THE
NATIVE ALUMINOUS EARTH
FROM SCHEMNITZ.

IN the pit called *Stephani-Schacht*, at *Schemnitz*, in *Hungary*, an earth was lately dug up, which is there reckoned to be aluminous earth, naturally quite pure and free from ſilex. It is as white as ſnow, light, crumbling, very friable; it ſtains but moderately, and adheres to the tongue*.

I put this earth to the trial in the following manner:

a) *One hundred* grains of it were expoſed to a ſtrong red heat for one hour in a covered crucible. After refrigeration, I obſerved in it a loſs of weight of 42 grains; which, it is obvious, was only the weight of the particles of water driven out by the fire. No alteration was effected by this in the exterior appearance of the earth; except that the pieces were made a little rifty, and diminiſhed in ſize.

b) Another *hundred* grains of this earth were gradually conveyed into dilute ſulphuric acid. They diſſolved in it without efferveſcence, yet accompanied by an obſervable diſengagement of caloric. The ſolution proved perfectly limpid; but upon evaporation it formed a clear and tranſparent coagulum, the ſurface of which, after a few days, appeared to be covered with a quantity of ſolitary, pyramidal, cryſtalline ſhoots. The maſs was next drenched

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* A fuller deſcription of it has been given by *Fichtel*, in his *Mineralogiſche Aufsätze*. Vienna, 1794. page 170.

and

and digeſted with an abundance of water; and then *ſiliceous earth* ſeparated, weighing 14 grains, when collected by filtering, and ignited.

c) When the ſolution, thus freed from the ſilex, had been combined with the requiſite portion of pot-aſh, and cryſtallized, it afforded pure alum; from which the aluminous earth was afterwards precipitated by means of pot-aſh, and purified in the manner frequently mentioned.

Hence the diſcovered conſtituent parts of this earthy foſſil amount to:

Ignited Alumine	*c*)	45
Silex	*b*)	14
Aqueous particles loſt by ignition		42
		101

The chemical knowledge of this earth is chiefly remarkable on this account, that hitherto, with the exception of ſome gems, no other mineral ſubſtance has been known, which conſiſts of alumine and ſilex in ſuch proportions that the quantity of the firſt ſo far exceeds the ſecond. Whereas in the ſpecies of clay, ſtrictly ſo called, for inſtance in the porcelain clay, the alumine which they contain is uſually but equal to a *fourth*, or at moſt a *third* part of the ſilex. Whence it follows, that in the above foſſil, the two conſtituent parts of clay are to each other preciſely in the inverſe ratio of that, in which they commonly exiſt in clay.

From the above reſults it is likewiſe evident, that this earth is by no means *abſolutely pure alumine*, as has been ſuppoſed. As the only inſtance of alumine of that degree of purity, therefore, we muſt ſtill conſider that earth which is found at *Glaucha*, near *Halle*, on the river *Saale*, in ſingle kidney-form pieces; although its true origin yet remains a problem to be ſolved.

XVIII.

XVIII.

CHEMICAL RESEARCHES
INTO
STRONTIANITE,
COMPARED WITH
*WITHERITE**.

SEVERAL properties, which *Strontianite* has in common with thoſe of *Witherite*, ſeemed to juſtify its being taken, when firſt diſcovered, for a ſpecies of the native carbonat of barytes. However, by the circumſtance of paper, dipped in a nitric ſolution of ſtrontianite and dried, burning with a red flame, I was induced to conjecture, that this foſſil might, perhaps, be diſtinguiſhed from witherite by other properties. This ſuppoſition was ſtrongly ſupported by the reſult of the chemical examinations inſtituted by *Sulzer* upon this ſubſtance, as well as by the experiments which *Blumenbach* has made upon animals.

It was probably the difficulty of obtaining ſtrontianite in ſufficient quantity, that has prevented the repetition and confirmation of thoſe experiments; in conſequence of this, the preſent additional eſſay, tending to procure a more accurate knowledge of it, may be deemed not ſuperfluous.

But in order the better to compare the properties and chemical relations or habitudes of ſtrontianite compared with thoſe of witherite, I have thought it proper to place together the reſults of an examination into each.

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* *Chemiſche Annalen*, 1793. 2 B. page 189. and *ditto*, 1794. 1 B. page 99.

Both theſe foſſils belong to thoſe products of nature, that have been diſcovered only within the laſt ten years.

a) The place at which the *ſtrontianite* was found the firſt time is *Strontian*, in *Scotland*; where this foſſil breaks in a vein of lead, together with ponderous ſpar (ſulphat of barytes), in a mountain chiefly conſiſting of gneiſs*. It is found maſſive, in oblong coarſely fibrous pieces, accumulated in bundles. It is of a light green, a little tranſparent, ſhining, and moderately hard.

Its ſpecific gravity I found to be 3,675.

According to the experiments which *Blumenbach* has made with regard to the effects of ſtrontianite upon animal life, it was found to poſſeſs nothing of the deleterious properties of witherite; as the former was eaten by animals without injury.

b) The *witherite*, or native carbonat of barytes, is dug in the lead-mines at *Anglezark*, in *Lancaſhire*; where, together with the foliated ſparry barytes, it forms the *gangue*, or earthy matter, ſerving as a matrix to the galena. The miners and inhabitants of that vicinity have been long ago acquainted with this mineral, denominated by them *Rats-ſtone*, as containing a poiſon fatal to animals. The reaſon, why the geognoſtic ſituation and the true native place of witherite (falſely ſtated to be *Alſton-Moor*, in *Cumberland*) continued for ſome time miſunderſtood, was the concealment practiſed by the miners of that place, who, from its weight, ſuſpected it to contain ſome noble metal; and perhaps alſo to the baſe intereſtedneſs of the uſurious dealers in foſſils.

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* This mountain is ſaid by others to be granitic; however, the ſtony matter adhering to my ſpecimens of ſtrontianite proves it rather to be gneiſs.

The colour of witherite is grey-white. It uſually occurs in conſiderable maſſes, and only occaſionally in ſix-ſided priſms, terminated by hexahedral pyramids. Thin fragments of it tranſmit the light. Its longitudinal fracture is gloſſy, and feebly ſtriated; but its croſs-fracture is only glittering and uneven. Its hardneſs is but middling; and its ſpecific gravity is 4,300, and therefore more conſiderable than that of ſtrontianite.

A ſecond place at preſent known, where native carbonat of barytes occurs, is the *Schlangenberg*, in *Siberia*. There it is met with of a grey-white colour, in the form of a ſtalactitical incruſtation, reſembling chalcedony.

FIRST EXPERIMENT.

a) *One hundred* grains of *ſtrontianite* in coarſe fragments, and put into a porcelain-veſſel, were ignited during the ſpace of two hours in a wind-furnace. Their figure was not ſenſibly altered by this; but their bright-green colour, their luſtre, and tranſparency, were deſtroyed. On weighing them, while yet hot, I obſerved a loſs of weight of no more than half a grain; and this loſs ſeems to be merely that of the moiſture expelled.

This experiment I repeated with another 100 grains; but expoſing them for five hours to a fire of ſuch intenſity, as to be capable of converting white marble into quick-lime, in but half that time. By this much ſtronger and more laſting red-heat, they loſt 6½ grains of weight. Hence, ſubtracting the above half grain, which, on account of the previous ignition, may be deemed watery parts, it follows, that ſix grains of *carbonic acid* were thus driven out. This burnt ſtrontianite gave a cauſtic taſte. I triturated and boiled it with four ounces of water, which I ſeparated again by filtration. The taſte of this much reſembled that of freſh and ſtrong lime-water. Two ounces of it were put aſide in a ſlightly covered glaſs. After a few minutes it was already covered with a white earthy pellicle; which continued to form anew for ſeveral days, as ſoon as the preceding had been broken by agitation, and thereby cauſed to fall down in thin lamellas. When no more was produced, I collected theſe lamellas; and they weighed ſeven grains after drying. Diſſolved vegetable alkali was then added to a part of the water, which had been boiled with burnt ſtrontianite. The mixture became milky, and depoſited carbonated ſtrontian-earth in a fine pulverulent ſtate. Into another part of that water I inſtilled ſulphuric acid, whereby a flocculent ſediment of ſulphat of ſtrontian-earth immediately precipitated. A third portion of this water was mixed with corroſive muriat of mercury (corroſive ſublimate), which was immediately decompoſed; ſo that the metallic oxyd exhibited at firſt a brown-red, and, upon farther affuſion of water, an orange-yellow-colour.

Therefore, notwithſtanding the violent ignition which it had ſuſtained, only a ſmall part of ſtrontianite had been deprived of its carbonic acid by this experiment; while the other portion ſtill efferveſced with acids as ſtrongly as the freſh unburnt ſtrontianite.

b) For a comparative experiment, I ſubjected *one hundred* grains of *witherite* in a porcelain-crucible to the ſame degree of red-heat, and for the ſame time of five hours.

Its form was no otherwiſe changed thereby, than that its bulk became ſomewhat increaſed; but its tranſparency was entirely gone; and its colour then inclined to a blueiſh milk-white. Nor was its weight found to be conſiderably diminiſhed, by weighing it while yet hot. The water, that had been boiled with it, as in the foregoing experiment, could not be diſtinguiſhed from pure water, neither by the taſte, nor by re-agents. Corroſive ſublimate diſſolved in it without turbidneſs; and it likewiſe continued perfectly limpid, on dropping ſulphuric acid into it. The ignited witherite alſo yielded, on the ſubſequent affuſion of muriatic acid, the ſame quantity of carbonic acid gas, which is extricated from it, when in the crude ſtate.

SECOND EXPERIMENT.

a) I cauſed a piece of *ſtrontianite*, of about half an ounce in weight, to be expoſed, in a clay-crucible, to the moſt vehement heat of the porcelain-furnace. When the veſſel had been returned to me, the ſtrontianite was found to have attacked and diſſolved the clayey maſs of the crucible, and to have run with it into a clear chryſolite-green, very hard, and denſe glaſs.

b) The piece of *witherite*, which, by way of reciprocal experiment, had been expoſed in the ſame manner to the ſame fire, and under the ſame circumſtances, had likewiſe ſtrongly acted on the crucible, and was converted into a hard, greeniſh glaſs, which, however, was not perfectly compact, but held ſome air-bubbles.

I repeated this experiment, but with this variation, that I weighed accurately 100 grains of each of theſe two foſſils; and I alſo exactly noted the weight of the clay-crucibles,

bles, which had previouſly ſuſtained a violent ignition. By this vitrification the *ſtrontianite* loſt 30, and the *witherite* 22 grains; which loſs of weight exactly agrees with the proportion of carbonic acid contained in each of thoſe minerals, as will appear from the ſequel.

THIRD EXPERIMENT.

a) In order to aſcertain the habitudes of *ſtrontianite*, when expoſed to the degree of heat requiſite to the baking of porcelain, and debarred from immediate contact with the crucible, I inſerted one piece of it, weighing 160 grains, into a cavity made in a compact piece of charcoal, and cloſed that cavity with a ſtopper, likewiſe made of charcoal. This piece of charcoal was then ſecured in a well luted melting-pot, which I ordered to be put upon that part of the porcelain furnace, where the fire acts in the moſt intenſe degree. Upon opening the pot, which was brought to me from the furnace while yet warm, I found the outſide of the coal in part conſumed*, and hence leſſened in its volume; but the middle and inner part was not in the leaſt impaired. The ſtrontianite which had been incloſed in it and burned, re-appeared in its former ſhape, without any mark of fuſion; but with ſome diminution of its brightneſs. Its hardneſs ſeemed to have increaſed, rather than decreaſed, and the colour was outwardly changed to a grey. The loſs of weight amounted to 49½ grains, making 31 in the hundred; and by this it appears, that the ſtrontianite had now been entirely deprived, both of its ſlight portion of water, and likewiſe of all its carbonic acid; as will be confirmed by the ſucceeding experiments.

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* This phenomenon I have always obſerved, when employing a ſimilar apparatus. The pores of the crucible are probably more opened by the vehemence of the heat; ſo that ſome conſumption of the coal may take place on the outſide.

When it had been reduced to powder, and twice boiled with water (one pound of the fluid each time), it entirely diſſolved in it; leaving only an inconſiderable reſidue, which, beſides ſome adhering coal-duſt, chiefly conſiſted of lamellas of carbonated ſtrontian, which was rapidly regenerated.

In the *firſt* of theſe decoctions, which immediately after filtration had been preſerved in a ſtopped glaſs bottle, there appeared cryſtals in half an hour's time, which viſibly increaſed, and formed an exceedingly beautiful group. Theſe cryſtals were clear and tranſparent, of a needle-ſhaped figure, and aggregated in filiform, knit, or interwoven planes. The whole of them bore reſemblance to the cryſtals of muriated ammoniac: or rather, conſidering the moſtly upright and cellularly implicated facets, which are formed by the accumulation of plumoſe cryſtals, it reſembles the native ſilver of Potoſi, dendritically cryſtalliſed in large laminas.

However, this cryſtallization of calcined ſtrontian-earth in ſimple water, without the acceſs of other extraneous ſubſtances, is on its own account highly remarkable; even without noticing the beauty of its cryſtals. This phenomenon is entirely new, and the firſt inſtance of an artificial cryſtallization of a ſimple earth in mere water.

The *ſecond* decoction of the burned ſtrontianite, that was kept in another glaſs, likewiſe afforded, after a few days, ſome ſolitary cryſtals. Theſe, however, had not the plumoſe appearance of the foregoing, but were minute, oblong, quadrangular plates, ſharpened on the edges.

The water decanted, proved ſtill of a ſtrong cauſtic taſte, and depoſited carbonat of ſtrontian, when carbonated alkali had been dropped into it. The cryſtals themſelves affected the tongue with the like corroſive taſte. By expoſure to air, they turned opake and milk-white. A part of them, immerſed in muriatic acid, diſſolved in it; yet no air at all was developed; and at the ſame moment I obſerved acicular cryſtals of muriated ſtrontian-earth ſhooting in the ſolution.

By treating *witherite*, on ſeveral repeated experiments, in crucibles formed of charcoal, for the purpoſe of depriving it entirely of its carbonic acid, I could never completely ſucceed. That foſſil penetrated, and in ſome manner conſumed the ſubſtance of the charcoal; and it was again found at the bottom of the outer clay-crucible, in a ſtate of ſemi-fuſion.

FOURTH EXPERIMENT.

a) As, in theſe experiments, I had given the preference to muriatic acid, I firſt endeavoured to aſcertain what quantity of it would be required to diſſolve a certain portion of *ſtrontianite*. With this view I mixed 100 grains of muriatic acid, of 1,140 ſpecific gravity, with 50 grains of water, and introduced into this menſtruum pure fragments of ſtrontianite, weighing, in the whole, 62½ grains. After the acid had been fully ſaturated with it, without the aſſiſtance of heat, there remained ſeven grains; hence 55½ grains were diſſolved and ſpent in the ſaturation of the acid. The action of the acid was vigorous, and the ſolution proceeded with a pretty ſtrong efferveſcence. It was neceſſary to weaken the muriatic acid with half its quantity of water, becauſe, when concentrated and alone, it ſhews but a weak operation.

Guided by this experiment, I took a quantity of muriatic acid ſufficient to diſſolve 100 grains of ſtrontianite, and having diluted it with half its quantity of water, I put it upon the balance, and equipoiſed it on the other ſcale. Theſe 100 grains of ſtrontianite were then gradually conveyed into the menſtruum, and thus the weight of the carbonic acid, diſengaged, was found to be 30 grains.

Therefore, *ſtrontianite* contains, in an *hundred* parts,

Strontian earth	69½
Carbonic acid	30
Water	½
	100

b) To find in the comparative experiment, which I intended to make with *witherite*, the proportion of muriatic acid requiſite to its ſolution and ſaturation, I prepared a mixture of 100 grains of muriatic acid with 200 of water; this degree of dilution being neceſſary, to render that acid capable of acting with full energy upon that mineral, and producing a clear ſolution. Into this mixture were then put 76 grains of witherite, in coarſe pieces. The ſaturation of the acid was accompanied by a ſtrong efferveſcence, and only three grains remained undiſſolved. One hundred grains of muriatic acid, therefore, required 73 grains of witherite, to be completely ſaturated; and, conſequently, 17½ grains more of it than of ſtrontianite.

In conſequence of this proportion of muriatic acid to witherite, I now introduced 100 grains of this foſſil into a ſufficient quantity of that menſtruum, which alſo I previouſly brought to an equilibrium upon the balance. When its ſolution was accompliſhed, the quantity of carbonic acid gas eſcaped amounted to 22 grains.

Hence, in *hundred* parts of *witherite* are contained,

Barytes	78
Carbonic acid . . .	22
	100

FIFTH EXPERIMENT.

a) If the muriatic ſolution of *ſtrontianite* be in part evaporated by a low heat, the *middle*, or earthy ſalt, will ſhoot in it into fine, longiſh, needle-ſhaped, but often, likewiſe, into larger priſmatic cryſtals, which continue perfectly dry in the air, but readily diſſolve in water.

If, upon theſe cryſtals, a ſufficient quantity of ardent ſpirit, not too much dephlegmated, be poured, and put in a warm place, they are diſſolved by it. The alkohol acquires, by them, the property of burning with a pleaſing carmine-red flame, if printing-paper, cotton, and ſuch looſe bodies are moiſtened with it, and ſet on fire.

b) The muriatic ſolution of *witherite*, on the contrary, yields oblong hexagonal tables of a much more conſiderable ſpecific gravity; and likewiſe theſe cryſtals require a greater quantity of water to be diſſolved than the others. Their ſolution, in weak ſpirit of wine, when ſet on fire, does not ex-

exhibit the leaſt trace of the red colour in the flame, by which that of ſtrontianite is ſo remarkable. The ardent ſpirit burns, in this caſe, only with a yellowiſh-white flame.

SIXTH EXPERIMENT.

a) The ſolution of *ſtrontianite*, in nitric acid, is likewiſe eaſily effected. Out of 100 grains of the foſſil employed, 30 grains of carbonic acid gas were diſengaged, as took place in the fourth experiment, by means of the muriatic acid. The nitrat of ſtrontian, which is afforded by this ſolution, when brought within a ſmaller compaſs, by a ſlow evaporation, forms cryſtals, which are clear and permanent in the air, the fundamental figure of which ſeems to be the double quadrilateral pyramid (octahedron), with its uſual variations.

b) Nitric acid, employed for the ſolution of *witherite*, muſt be more liberally diluted with water, to prevent the too rapid formation of the cryſtals, which would otherwiſe take place. Theſe, likewiſe, ſeem to be nearly octahedrons; they are, however, leſs diſtinct, and, in part, more of a tabular figure. They are, beſides, diſtinguiſhed from thoſe of ſtrontianite, by being leſs clear, and by their dull and opake appearance.

SEVENTH EXPERIMENT.

a) By acetic acid *ſtrontianite* is acted upon with little energy. I boiled vinegar, diſtilled and concentrated by freezing, upon finely ground ſtrontianite, and gently evaporated the liquor filtered off from the undiſſolved reſidue. It afforded ſmall and clear cryſtals, that did not deliqueſce in the air, and the figure of which appears to conſiſt of thin rhombic tables.

b) An acetic ſolution of *witherite*, prepared in the ſame manner, aſſumed, at a raiſed temperature, a tenacious conſiſtence, and congealed upon cooling into a maſs, reſembling zeolite of the fine fibrous texture. Another ſolution of this kind, which I left to evaporate ſpontaneouſly in a ſhallow diſh under free acceſs of air, I obſerved to have cryſtallized in recumbent, very beautiful, ramified dendritic figures of a milk-white colour; or, ſtrictly ſpeaking, it dried in that form. When this *acetite of barytes* had been rediſſolved in water, it then ſhot into regular and permanent cryſtals, forming long, thin, quadrilateral columns, obliquely truncated at their ends.

EIGHTH EXPERIMENT.

a) Upon 60 grains of pulverized *ſtrontianite*, introduced in a retort, I poured, by degrees, two ounces of concentrated ſulphuric acid. The firſt portion that was affuſed cauſed a great frothing. The contents of the retort were then brought to boiling in a ſand-heat. After cooling, the earth was found entirely diſſolved, and the ſolution colourleſs. But it is again decompoſed, as ſoon as any water is added. If only a few drops of water are inſtilled into it, it coagulates, and becomes milk-white. One ſingle drop of this ſolution, thrown into four ounces of water, renders this laſt turbid, and ſulphated ſtrontian-earth falls down.

The concentrated ſolution afforded, after ſome days, ſmall, bundled, and ſtellated cryſtallizations, the radii of which, as it ſeemed, were formed by minute quadrangular columns.

b) In like manner, 60 grains of *witherite* were combined with two ounces of ſtrong ſulphuric acid. A great efferveſcence enſued; and, with the aſſiſtance of boiling heat, a complete ſolution, as clear as water, was likewiſe, in this caſe, produced. Some days after, the greateſt part of this ſolution formed a cryſtalline maſs, of very tender fibres. This ſolution was alſo immediately decompoſed by the admixture of water, and ſulphat of barytes precipitated.

NINTH EXPERIMENT.

a) I decompoſed a ſolution of 100 grains of *ſtrontianite* in muriatic acid, previouſly diluted with ſufficient water, by means of mild vegetable alkali. The earth again took up from the precipitating medium that quantity of carbonic acid, of which it was deprived during its ſolution in the muriatic acid. When edulcorated and dried, it again appeared with its former weight of 100 grains.

b) *Witherite* exhibits the very ſame habitude in this point. From 100 grains of it, diſſolved in that acid, and afterwards precipitated by carbonat of pot-aſh, I likewiſe recovered 100 grains.

TENTH EXPERIMENT.

It is, however, to be obſerved, that in theſe combinations of the reſpective earths of the *ſtrontianite* and *witherite* with carbonic acid, made by art, this laſt conſtituent part is not ſo obſtinately retained by them in a read-heat, as it is when both exiſt in their natural ſtate.

a) For, when I expoſed 100 grains of precipitated *ſtrontian-earth* to intenſe red-heat during two hours, when upon this I boiled it in two ounces of water, and triturated two grains of corroſive ſublimate, with the water filtered off from that decoction, the mercurial oxyd would not diſſolve in it, but ſeparated of a yellow-brown colour.

The loſs of weight, ſuſtained by the ignited ſtrontian-earth, I could not determine with certainty, part of it having united with the body of the crucible. But the diminution of weight cannot have been of great importance; ſince the torrefied earth ſtill vehemently effervefced with acids.

b) Thoſe 100 grains of earth that had been precipitated from the ſolution of *witherite*, and were ignited in the ſame manner, adhered to the crucible with ſtill greater force. The water, with which that earth was boiled after its ignition, nearly in the ſame manner (*a*) precipitated the metallic oxyd from the ſublimed corroſive muriat of mercury. Likewiſe the ſolution of the precipitated earth in an acid, when poured upon it, was ſtill attended with effervefcence.

ELEVENTH EXPERIMENT.

Neither the ſolution of *ſtrontian earth*, nor that of *witherite*, is rendered turbid in the leaſt degree, or otherwiſe altered by cauſtic ammoniac, even when affuſed in great exceſs. But as ſoon as the ſlighteſt portion of an alkaline carbonat is afterwards ſuperadded, an immediate precipitation takes place.

TWELFTH EXPERIMENT.

a) Into a muriatic ſolution of 100 grains of *ſtrontianite* I dropped concentrated ſulphuric acid, adding it, by degrees, and till no more precipitate fell down. This, when duly waſhed, and deſiccated in the air, amounted to 114 grains. Of this ſulphat of ſtrontian-earth I digeſted 40 grains, in a boiling heat, with eight ounces of water. The undiſſolved reſidue, collected after cooling and dried, was found to weigh 37½ grains. Therefore, 2½ grains were diſſolved by eight

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eight ounces of water, which ſolution, upon the addition of carbonated alkali, yielded a tender precipitate.

b) *One hundred* grains of witherite diſſolved in muriatic acid, and precipitated by the ſulphuric, furniſhed 120½ grains of ſulphat of barytes, after being waſhed and dried in the air.

It is, then, evident, by the reſults of theſe experiments, that there ſubſiſts an abſolute and natural difference between the earth of *ſtrontianite* and that of *witherite*, or of barytes in general. For, although both theſe ſpecies of earth ſeem to be nearly of the ſame nature, with reſpect to their relations to the ſulphuric acid, as well as to the force with which they retain the carbonic acid in the fire; nevertheleſs many more circumſtances exiſt, which indicate their eſſential difference. Theſe are, principally,—the leſs ſpecific gravity of ſtrontianite compared with that of witherite; the difference of the habitudes of the carbonic acid combined with both of them; the various form of the cryſtals produced by the combination of theſe earths with the nitric, acetic, and, above all, with the muriatic acid; the power of ſtrontian-earth to cryſtallize in ſimple water; and principally, alſo, the red colour, which the earth of ſtrontian imparts to flame in various ways of preparation.

Since, therefore, the *ſtrontian-earth* is peculiarly diſtinguiſhed by the above enumerated properties, as well as in other reſpects, there is nothing that can prevent it from being acknowledged and eſtabliſhed as a *new*, *diſtinct*, and *ſimple earth*.

XIX.

XIX.

CHEMICAL EXAMINATION OF *LEPIDOLITE.*[*]

THE foſſil brought into notice, by the name *Lilalite*, was firſt taken for a ſpecies of gypſum, and then for a ſpecies of Zeolite. The firſt account publiſhed of it is that of *Born*, in the *Chemiſche Annalen*, 1791, B. 2. S. 196, where he writes of it as follows.

"At *Rozena*, in Moravia, there are found, between blocks of granite, uncommonly large and heavy maſſes of a denſe violet zeolite, whoſe texture, like that of the aventurino, exhibits white ſhining lamellas, that, at the firſt view, might be looked upon as micaceous particles. But theſe, on more accurate inveſtigation, are found to be nothing elſe but white lamellas of zeolite, having the luſtre of the mother of pearl. When ignited between coals, it fuſes to a porous ſlag. In a ſtrong fire it runs into a denſe, white glaſs, reſembling wax. At an increaſed heat its colour diſappears, which laſt ſeems to originate from manganeſe. Some pieces of this foſſil are firmly implanted on quarz; others are traverſed by granite; but, for the moſt part, it is perfectly pure, and its chief conſtituent part is ſilex.

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[*] *Beobachtungen und Entdeckungen aus der Naturkunde*, vol. v. 1 St. S. 59.

To this deſcription, given by *Born*, I may add, that the hardneſs of this ſtone is but inconſiderable, as it may be ſcraped with the nail of the finger. Notwithſtanding this, it is capable of ſome poliſh when cut into plates.

Its ſpecific gravity is but middling, viz. 2,816 *

The opinion of thoſe, who thought it to be a ſpecies of gypſum, (ſulphat of lime) I found totally unſupported. But how juſtly this foſſil may be ranked with the zeolites, will be underſtood from the reſult of the preſent analyſis, the ſubject of which was its amethyſt-red variety.

A.

a) When this foſſil is heated to redneſs upon charcoal, before the blow-pipe, it firſt frothes up moderately, but ſoon after it runs into a perfectly fuſed milk-white pearl, which, in moſt of its parts, is tranſparent; but, if broken by the hammer, yields fragments entirely clear.

b) By a neutral phoſphat it is gradually diſſolved, and then it fuſes into a ſemi-tranſlucid white pearl.

c) Vitrified boracic acid (glaſs of borax) diſſolves it more readily, and fuſes with it into clear colourleſs ſpherules.

d) On melting it with ſoda, in the ſilver ſpoon, it moderately boils, and a maſs, ſpeckled red and blue, is produced.

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* The external characters of Lepidolite are deſcribed by *Karſten*, loc. cit. pag. 91.

e) Expoſed to red-heat, in a ſmall crucible, for half an hour, it loſes its amethyſtine colour, and that of a light iſabella ſucceeds *.

B.

a) *Four hundred* grains of the levigated foſſil, mixed with the ſame quantity of carbonated pot-aſh, were expoſed to a moderate red-heat, in a porcelain crucible, for two hours. They did not fuſe, but concreted into a conſiderably firm maſs, which, being removed from the veſſel before cooling, had a dark verdigris colour, and in ſome parts an amethyſt red. Water which was poured upon it, after grinding, became tinged of a deep graſs-green. A few drops of nitric acid changed this green colour to a roſe-red. But as ſoon as ſulphureous acid has been added, it immediately deſtroyed this laſt colour, and the fluid, under examination, was rendered colourleſs. This change of colour, therefore, indicated, that the red colour of the foſſil is owing to a portion of mangneſe.

b) I ſaturated that alkaline fluid with muriatic acid, added to exceſs, and the ſolution of the ſoluble parts was aſſiſted by digeſtion. This muriatic ſolution, exhibiting a bright yellow colour, was ſeparated from the *ſiliceous earth* by filtration; which laſt proved very much inflated, and, when waſhed, deſiccated, and ignited, weighed 212 grains.

c) After the muriatic ſolution had been concentrated, by diſtillation from a retort, it ſtill depoſited ſome *ſiliceous earth*, amounting to four grains after ignition. By its ſubſequent combination with Pruſſian alkali, a dirty blueiſh precipitate, of a woolly flocculent form, was thrown down, which, upon ignition, gave a reſidue of four grains, conſiſting of intermingled light-brown and grey-white particles. This reſidue was little, if at all, attracted by the magnet. When fuſed with phoſphated alkali, it formed a milk-white and ſemi-tranſlucid pearl. Glaſs of borax gave it firſt a green, and then a garnet red colour. Soda produced with it a black ſcoria, in which, with the help of the microſcope, extremely minute, ſilver-white metallic globules could be ſeen.

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* Concerning the habitudes of Lepidolite, in the fire of the porcelain-furnace, ſee N. 54 of the 1ſt Eſſay.

The portion of iron that was contained in the quantity of pruſſiated pot-aſh, requiſite to effect that precipitation, makes *one* grain; which being ſubtracted, there remain three grains for the iron and the manganeſe, conſtituting the metallic contents of the ſtone.

d) I now mixed the ſolution with cauſtic (pure) ammoniac. A copious precipitate, in the form of flour-paſte, fell down, which I directly ſeparated by filtering. When edulcorated, dried, and expoſed to gentle red-heat, it was found to be aluminous earth, of 152 grains in weight.

e) The fluid remaining, after the ſeparation of the argil, was combined with carbonated alkalis; but no new precipitate enſued. Therefore, I evaporated the liquor to dryneſs, diſſolved again the ſaline maſs in water, and collected the ſlight portion of earth which then ſeparated. It weighed three grains, conſiſting of two grains of *ſilex* and one grain of alumine.

In the above decompoſed 400 grains of the foſſil, therefore, exiſted:

Ignited *ſilex*	B. *b*)	212	218 gr.
	c)	4	
	e)	2	
Alumine	*d*)	152	153
	e)	1	
Manganeſe and oxyded *iron*	*c*)		3
			374

Which gives for *one hundred* parts,

Silex	54,50
Alumine	38,25
Manganeſe and *oxyd of iron*	0,75
	93,50
Loſs in *aqueous particles*	6,50
	100

C.

As the fuſibility of lepidolite, without addition of any extraneous ſubſtance, induced me to ſuſpect, that, among its conſtituent parts, ſome *calcareous earth* might be found, I reſolved to repeat its analyſis.

For this reaſon, I again ſubjected 400 grains of it to the ſame analytical proceſs. Having ſeparated the ſiliceous earth, the quantity of which was the ſame in proportion with that of the firſt proceſs, I treated the ſolution, then obtained, with mild vegetable alkali, and at a raiſed temperature. The precipitate produced in the proceſs, and waſhed, was divided into four equal parts while yet moiſt.

a) Upon one fourth part I affuſed *dilute ſulphuric acid*, which ſoon diſſolved it into a weak reddiſh liquor. After a ſhort repoſe, a reddiſh-grey ſediment fell down, which, carefully collected and dried, weighed half a grain, and readily fuſed upon charcoal to a black-grey ſcoria. When a ſmall portion of this laſt had been thrown into melted phoſphoric ſalt, it gradually diſſolved, and gave a green tinge to the ſaline bead. But when the whole of it was put in, the ſmall globule loſt its tranſparency and aſſumed a blue colour. At the ſame time a very minute grey-white metallic grain became diſcernible, which, when ſeparated from the ſpherule, would not obey the magnet. As that metallic bead hardly weighed 1/32 of a grain, it would not admit of farther inveſtigation. Perhaps it was *phoſpat of iron.* The ſaline bead, by imbibing moiſture, was again diveſted of its blue colour, and turned brown-red.

The ſulphuric ſolution, left in a colourleſs ſtate, after the ſeparation of the above depoſition, was committed to ſpontaneous exhalation; and it then ſhot, by degrees, into perfect cryſtals of alum. At laſt there remained a thickiſh reſidue, which, previouſly diluted with water, and warmed, I combined with vegetable alkali. A ſlight quantity of a looſe, whitiſh precipitate fell down of ⅓ grain in weight, when edulcorated and dried. By expoſure to air, it acquired a brown colour, and by ignition upon charcoal it became black. Treated with a neutral phoſphat, with the aſſiſtance of the blow-pipe, it ſoon melted to a ſmall globule, which, by turns, appeared colourleſs, when acted on by the inner flame, and amethyſt-red, by the outer-flame. Thus it proved to be *mangan*eſe.

b) Upon another fourth-part of the precipitate, vinegar, diſtilled and concentrated by freezing, was affuſed, and decanted again from it, after 12 hours. In order to try this acetous liquor for calcareous earth, it was divided into three parts, each of which was ſeparately treated; one, with *oxalic acid*; another, with *oxalat of pot-aſh*; the third with *ſulphuric acid.* But in no caſe any indication of lime was obſervable; all theſe three trials remaining perfectly clear. The acetous ſolution merely contained ſome of argil, which I precipitated from it by pot-aſh.

c) The third portion of the precipitate, likewiſe before drying, was introduced into heated *cauſtic alkaline lye*: it liquefied in it, leaving a ſmall browniſh reſidue, conſiſting of the above mentioned metallic ingredient of the ſtone, together with a ſlight trace of ſilex.

d) Laſtly, the remaining fourth-part of the yet moiſt precipitate I ſuffered completely to deſiccate in a warm place. The earth was of a milk-white, and weighed 54 grains. It loſt nothing of its colour, and but little of its bulk, by a ſtrong ignition for two hours in a ſmall and covered crucible. But its weight was the more diminiſhed, as it then weighed 37½ grains only.

Therefore, the reſult of the firſt analyſis was confirmed, as to the main point, by this ſecond decompoſition of lepidolite.

But the total abſence of *calcareous earth*, in the mixture of this foſſil, is highly worth remarking. For ſilex and argil, when in their pureſt ſtate, are abſolutely infuſible in any proportion of the mixture; but become fuſible, when lime in a proportionate quantity enters into the combination. On the contrary, the lepidolite, conſiſting merely of ſilex and argil, and without any portion of lime, is of ſo eaſy fuſion, that it properly may be reckoned among the moſt fuſible ſtones.

In many caſes, the metallic oxyds, indeed, likewiſe act as powerful fluxing media; yet, in the preſent inſtance, the metallic portion is too ſmall to be capable of being conſidered, with any degree of probability, as the cauſe of the fuſibility of this foſſil.

Is there, perhaps, in thoſe argillaceous ſtones that fuſe in the fire, without any admixture either of abſorbent earths or of metallic calces being found in them, ſome hidden principle, promoting their fuſion, which is hitherto unknown, and is of a volatile nature? Fel-ſpar affords an inſtance of them. This ſtone, while continuing in its natural unaltered ſtate, runs into a glaſs; whereas porcelain-clay, which reſults from its decay, is infuſible in the higheſt degree. Therefore, it might not ſeem unreaſonable to ſuppoſe, that during this tranſition of vitrifiable fel-ſpar into infuſible clay, ſome volatile ſubſtance, as yet unknown, and capable of promoting fuſion, might eſcape; did we not, on the contrary, find, by experience, that vitrified fel-ſpar, if again expoſed to fire, enters again into fuſion, in the ſame manner as it did the firſt time.

It remains yet to inveſtigate, whether the lepidolite is juſtly ranked, as *Born* would have it, among the zeolites. When we attempt, in the mineralogical ſyſtem, to ſeparate and to determine the various ſpecies of foſſils, not in a vague manner, but according to fixed characters; the queſtion is, then, in which of its properties does the ſpecifical character of zeolite conſiſt? I think, in the following: that it is moderately hard, and gives no ſparks with ſteel; that, urged by the flame upon charcoal, it is rendered milk-white and opake, ſwelling much at the ſame time, and forming ramoſe excreſcences, yet without actually fuſing into a globule; and that, beſides the ſiliceous and aluminous earths, the calcareous, likewiſe, is an eſſential conſtituent part of it. The mother-of-pearl-like luſtre, the gelatinous coagulum, which it forms with acids, and its phoſphoreſcent nature on ignition, cannot be conſidered as any of its eſſential properties.

Since, therefore, the preſent foſſil does not ſhew the ſame appearances upon charcoal as the zeolite, but as it intumeſces but moderately, while, at the ſame time, it fuſes into a perfect, and, in part, tranſlucid, round globule; and, moreover, as it is abſolutely deſtitute of lime for one of its conſtituent parts, theſe facts afford ſufficient ground to diſtinguiſh it from zeolite, in the ſyſtematical arrangement of foſſils, and to rank it as a diſtinct ſpecies.

As I entertained ſome doubts whether the name *Lilalite*, given to that foſſil at its firſt introduction into public notice, would bear ſound criticiſm, I recommended, in its ſtead, the denomination of *Lepidolite* (ſcale-ſtone), for its *ſpecific name*; becauſe this foſſil ſhines on its fracture like an aggregate of minute fiſh-ſcales*.

A particular foſſil has lately been diſcovered in the vicinity of the lepidolite, which conſiſts of long columnar cryſtals, longitudinally ſtriated, and tranſverſing grey-white quarz, and occurs, with various degradrations, of a pale-red colour, in ſome ſpecimens paſſing into the iſabella, and into green. This mineral was pretended, by ſome, to be *cryſtallized lilalite:* but, even without having yet performed a perfect analyſis of it, I am already convinced, that it by no means belongs to that foſſil, but to the *ſhörlaceous beryl*, (ſhörlite,—by Kirwan); with which it agrees not only in its extarnal appearance, but alſo in its habitudes, in the dry way.

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* A more accurate account of the native place of Lepidolite, together with a full deſcription of its external characters, may be ſeen in *Fichtel's Mineralogiſche Aufſaetze*, Vienna, 1794, page 126. There the author alſo endeavours to defend the name *Lilalite*, given to this ſtone by its firſt diſcoverer, the Abbé *Poda*, of *Neuhaus*, againſt mine, *Lepidolite*. But, in my opinion, that appellation is erroneous: 1ſt, becauſe it is againſt the common rule to derive the names of *ſpecies* from colours, ſince theſe are changeable, and ſince even this very foſſil has already been met with, in various ſhades, of *violet blue*, *amethyſt red*, and *white*, beſides the *lilac* colour, of which the diſcoverer firſt found it. 2dly, Becauſe the word *Lilalite*, being compounded of the Arabic (*Lilac*, *Lilach*), and the Greek (*Lithos*, ſtone), is a *nomen hybridum*.

XX.

CHEMICAL EXAMINATION

OF

CIMOLITE.

THE *Cimolic earth* (Cimolia Plinii), or the *Cimolite*, as I ſhall call it for the ſake of brevity, belongs to thoſe bodies of the mineral kingdom, of which an hiſtorical knowledge has, indeed, reached our age, from the writings of ancient claſſics, ſuch as *Theophraſtus*, eſpecially, *Dioſcorides* and *Pliny*; but a familiar acquaintance with them has gradually been loſt ſince the time of thoſe authors. We learn from the works of thoſe old naturaliſts, that the Greeks, as well as the Romans, beſides its medical uſe, employed the cimolic earth for technical purpoſes, in the preparation and cleaning of their ſtuffs and wearing apparel. This is ſhewn, among others, in the following paſſage of Pliny[*] :—*Cretæ plura genera. Ex iis* Cimoliæ *duo ad medicos pertinentia : candidum et ad purpuriſſum inclinans.* And having firſt mentioned its various applications in medicine, he thus continues : *Eſt et alius uſus in veſtibus. Nam ſarda, quæ adfertur e Sardinia, candidis tantum adſumitur, inutilis verſicoloribus : et eſt viliſſima omnium Cimoliæ generum. Pretioſior* Umbrica, *et quam vocant* Saxum.—*Primum abluitur* veſtis Sarda, *dein ſulphure ſuffitur : mox deſquamatur Cimolia, quæ eſt* coloris veri. Fucatus *enim deprehenditur, nigreſcitque, et funditur ſulphure.* Veros *autem et* pretioſos colores *emollit Cimolia, et quodam nitore exhilarat contriſtatos ſulphure.*

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[*] Hiſt. Natural. lib. xxxv. chap. lvii.

What later writers have mentioned concerning cimolite (*Agricola*[*], for inſtance), are mere compilations taken out of thoſe ancient authors. *Tournefort*, however, is to be excepted, who certainly ſaw it in his travels through the Levant, but has erroneouſly taken it for an earth of the calcareous kind, diſtinguiſhed from common calcareous earth, as he thought, by its ſoapy fatneſs.

It is by the kind communication of *John Hawkins, Eſq.* who, in his voyage to the Grecian iſlands, made for the advancement of Natural Hiſtory, has collected the genuine cimolic earth on the iſland *Cimolo* itſelf, or *Argentiera*, as it is called at preſent, that I have been enabled to revive the knowledge of this foſſil, hitherto loſt both to Natural Hiſtory and Technology, and, at the ſame time, to undertake its chemical analyſis.

The *colour* of cimolite is a light greyiſh-white, inclining to pearl-grey. But this colour is ſomewhat changed by expoſure to air, where it acquires a reddiſh tint. It is, therefore, probable, that the *cimolia ad purpuriſſum inclinans*, of *Pliny*, as well as his *candida*, are both one and the ſame ſpecies; ſince the firſt, or the externally reddiſh one, is, on the fracture, as white as the ſecond.

Cimolite is found *maſſive*, and probably it occurs in vaſt ſtrata. Its fracture is *earthy, uneven*, and its texture more or leſs *ſlaty*. It is thoroughly *opake*, and does *not ſtain*

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[*] *De Natura Foſſilium*, lib. ii.

conſiderably. When ſcraped with a knife, it yields ſhavings, like ſteatites, and the abraided ſurface is *ſmooth*, and of a *greaſy luſtre.* It adheres pretty firmly to the tongue.

Yet this ſtone, though it is ſo ſoft as to be ſcraped by the nail, is but with difficulty broken, and, in conſequence of this tenacity, not eaſily pulverized.

Its ſpecific gravity I found exactly double that of water; that is, 2,000.

Small milk-white cryſtalline grains of quarz are found here and there ſingly diſſeminated in its ſubſtance.

The ſlaty texture, which, in the dry pieces of cimolite, is often but confuſedly, perceived, appears moſt diſtinctly when they are ſteeped in water. Cimolite is immediately penetrated by water, and it then developes itſelf into thin laminæ, of a curved-ſlaty form.

Cimolite, if triturated with water, diſſolves into a ſoft, pap-like maſs, though not ſlippery in the ſtrict ſenſe. *An hundred* grains of it, ground with three ounces of water, aſſumed the appearance and conſiſtence of a thickiſh cream. When this maſs is left to deſiccate in the grinding-diſh, it detaches itſelf from its ſides, in hard-dried, ribbon-like, and ſomewhat flexible bands. In this ſtate, cimolite is pulverized with ſtill greater difficulty than before.

In order to obtain ſome knowledge of the efficacy and utility of cimolite, in a technical view, I partially greaſed ſmall pieces of ſilk and woollen cloth with oil of almonds, and covered thoſe oily ſpots, on both ſides, with cimolite, worked by grinding with water to the thickneſs of a liniment. They were then expoſed to dry in the air. The next day I dipped thoſe ſtuffs in water, and ſaw, with ſurprize, that, by a ſlight waſhing, the cimolite, together with all the greaſy ſpots to which it had been applied, were removed, without leaving the ſlighteſt trace. After drying, the ſtuffs were again found poſſeſſed of their former cleanlineſs, and the original beauty of their colours completely reſtored.

Trivial and imperfect as this experiment was, it ſerved, however, fully to confirm the technical uſe of cimolite, extolled by the ancient writers: and hence, too, it appears much to ſurpaſs the beſt Engliſh fuller's earth. To revive the importation of cimolite, as an article of merchandiſe, would therefore be very deſirable for the manufactures ſubſervient to our clothing, as well as for common uſe; eſpecially for precious ſtuffs of delicate colours, that will not well bear the agency of acids and alkaline ſoaps. Whence, alſo, the inhabitants of *Argentiera* make as much uſe of it, in the waſhing and bleaching of their ſtuffs, at this very day, as in remote ages.

To acquire a chemical knowledge of cimolite, I made the following experiments.

A.

a) *Hundred* grains of cimolite, in entire pieces, were expoſed, for half an hour, to the fire of the wind-furnace, in a covered crucible. After cooling, it was found groſsly ſplit into flaty fragments, of uneven ſurfaces. This was accompanied, at the commencement of ignition, with a ſurpriſingly ſtrong noiſe. The cimolite acquired, at firſt, a browniſh-grey colour, which, however, again diſappeared. It loſt 1·2 grains in weight.

b) Ignited, alone, upon charcoal, before the blow-pipe, it firſt turns dark-grey; but, after complete ignition, it again becomes white.

When cimolite is conveyed into *phoſphoric ſalt*, already fuſed, it is gradually diſſolved by it, and runs into a colourleſs pearl.

Glaſs of borax, likewiſe, diſſolves cimolite; but is tinged by it of a light-brown.

Soda fuſes with it into a milk-white globule *.

B.

Hundred grains of cimolite were triturated with water, and treated with 300 grains of ſtrong ſulphuric acid, by which management the white colour of the blended maſs was changed to a pale fleſh-red. For the purpoſe of ſeparating the ſiliceous earth, I evaporated the mixture in a warm temperature, covered it again with water, and ſubjected it to digeſtion. However, it continued turbid and muddy; ſo that I could not fully ſucceed in ſeparating the ſilex. I, therefore, employed that mixture to convince myſelf of the abſence, or preſence, of magneſia, among the conſtituent parts of that foſſil. With this view, I ſaturated it, with the aſſiſtance of heat, with mild calcareous earth,

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* The habitudes of cimolite, in the fire of the porcelain-furnace, have been mentioned at No. 27 of the firſt eſſay.

and

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and reduced the fluid, when filtered, to a ſmaller bulk, by evaporation; carefully removing, at the ſame time, the ſelenite, as it appeared. Yet no trace of ſulphat of magneſia was perceptible.

C.

a) *Two hundred* grains of cimolite, mixed, and ignited with thrice their quantity of cauſtic pot-aſh, afforded, after cooling, a blueiſh, and greeniſh-white maſs. From this, when ſoftened with water, the undiſſolved part was ſeparated by filtering.

b) The alkaline liquor had no colour. It at firſt continued clear, on being ſaturated with ſulphuric acid; but, at a raiſed temperature, it coagulated to the conſiſtence of jelly. Upon the affuſion of more water, and proper digeſtion, *ſiliceous earth* ſeparated, weighing 44 grains, when ignited.

c) The earth, which was not taken up by the alkali (*a*), was of a grey white, and weighed 220 grains. It diſſolved, by degrees, in ſulphuric acid, which was added to it, and left behind ſome *ſiliceous earth*, which weighed five grains, after ignition.

d) Both the ſulphuric ſolutions (*b*) and (*c*) were next added together, and partly evaporated; after which, cryſtals of alum appeared, as the liquor cooled. The remainder of the fluid congealed, on farther evaporation, to a jelly. When mixed with water, digeſted, and filtered, there remained *ſiliceous earth*, in the form of pellucid vitreous grains, the weight of which, after grinding and ignition, was 64 grains.

e) I now combined the ſolution with Pruſſian alkali, which produced a deep-blue precipitate; by the quantity of which the proportion of the ferruginous ingredient, in the form of *oxyd of iron*, attractible by the magnet, was determined at 2½ grains.

f) When the portion of iron had been ſeparated, I added a ſmall quantity of vegetable alkali to that part of the ſolution which yet remained. By this treatment, and ſubſequent evaporations, I obtained aluminous cryſtals, in ſucceſſion, to the end. But, at the ſame time, there ſtill ſeparated ſome *ſiliceous earth*, amounting to 13 grains, when heated to redneſs.

g) The whole of the alum (ſulphat of alumine) obtained, was re-diſſolved in water, and the argillaceous earth ſeparated by vegetable alkali. This argil, depurated and ignited, gave 46 grains in weight.

Therefore, the above 200 grains of *cimolite* produced :

Ignited *Silex*	C.	*b*)	44	126 grains.
		c)	5	
		d)	64	
		f)	13	
Alumine		*g*)		46
Ignited *oxyd of iron*		*e*)		2½
Loſs by ignition	A.	*a*)		24
				198½ grains.

Whence, *one hundred* parts of *cimolite* contain:

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Silex	63
Alumine	23
Oxyd of iron . . .	1,25
Water	12
	99,25

With regard to theſe conſtituent parts, and their proportions to each other, the *cimolite* might properly be placed in the mineralogical ſyſtem along with the common ſpecies of clay: but its diſtinguiſhing character, on which, alſo, its other phyſical properties depend, undoubtedly conſiſts in the minutely divided ſtate of the ſiliceous ingredient, as well as the moſt intimate mixture of this laſt with the argillaceous part.

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XXI.

CHEMICAL EXAMINATION

OF THE

MAGNESIAN-SPAR (*Bitterſpath.*)

(Cryſtallized Muricalcite, *Compound Spar*, of Kirwan.)

A*.

AMONG the Tyroleſe foſſils, and thoſe of Salzburg, ſo remarkable by their variety, there occur certain rhombic cryſtals, which are moſt frequently found ſingly interſperſed in a ſlaty chlorite (*Schneideſtein*), mixed with ſilver-grey magneſian lamellas. Thoſe cryſtals have been called *rhomboidal ſpar* on account of their figure, or *magneſian-ſpar* (*Bitter-ſpath*) on account of this ſuppoſed conſtituent part.

The colour of thoſe cryſtals is greyiſh-white, paſſing more or leſs into yellow or reddiſh. They commonly form regular rhombs, from one half to three fourths of an inch thick; but they are alſo found of a greater ſize. Their external ſplendour is only moderate; but internally they poſſeſs a high luſtre. Their fracture is of the ſtraight foliated kind; but the figure of their fragments is rhomboidal. They are moſtly *tranſparent* in a great degree; but the fragments of the larger cryſtals are nearly *pellucid*; and if held againſt the light, they exhibit changing rainbow-colours. Their hardneſs is a medium between that of calcareous-ſpar and that of fel-ſpar; as the firſt may be ſcratched by them, but they themſelves may be ſcratched by the ſecond [*].

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* *Beobachtungen und Entdeckungen aus der Naturkunde*, vol. v. page 51.

Their ſpecific gravity I have found to be 2,480.

a) An entire piece, weighing 100 grains, was ignited in a covered crucible for two hours; yet, notwithſtanding its ſparry texture, it remained entire, without flying in pieces. It was rendered aſh-grey, and wholly opake, though preſerving ſome luſtre. At the ſame time its weight was leſſened 45 grains [†].

b) The action of mineral acids upon magneſian-ſpar, while in groſs fragments, is not perceptible; but if pulverized, they attack and diſſolve it gradually, attended with a continued gentle effervescence. With the ſulphuric acid, ſelenite is generated, and the ſupernatant ſolution is of a pale-reddiſh colour. Nitric acid produces a colourleſs ſolution, and the muriatic acid a yellow one.

But when pieces of calcined magneſian-ſpar are employed, the ſolution goes on rapidly. And in that caſe the nitric acid leaves a metallic reſidue behind, which ſeparates of a brown-red colour.

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[*] More circumſtantial deſcriptions of the external characters of this foſſil have been given by *Karſten* in Beob. u. Entd. a. d. Naturk. vol. v. page 56.—*Born* Catal. d. l. Collect. d. Foſſils, vol. i. page 386, with the name, *Chaux magneſiée*;—and *Fichtel.* Minerl. Aufsätze, page 189.

[†] For the habitudes of *magneſian ſpar* in a porcelain-heat, ſee N. 16 of the firſt Eſſay.

c) *Three hundred* grains of finely powdered magneſian-ſpar, mixed with an equal quantity of pot-aſh, were ignited for two hours in a crucible. The maſs returned black out of the fire, except that its middle part was rendered of a dark aſh-grey. When triturated, and covered with water, it became light-green. Muriatic acid affuſed upon it, in ſufficient quantity, diſſolved the whole, forming a clear golden-yellow tincture.

d) This ſolution was decompoſed by means of carbonated pot-aſh, and with the aſſiſtance of heat. Sulphuric acid was poured upon the precipitate, previouſly diluted with water, in ſuch a quantity that the acid was predominant. Abundance of ſelenite (*ſulphat of lime*) was thus produced; which ſeparated from the remaining fluid.

e) I next evaporated the ſolution, that remained after the ſeparation of the ſelenite, and which contained ſulphat of magneſia, and a ſmall portion of ſulphated oxyd of iron; carrying on the operation, until the ſaline maſs appeared in a dry ſtate. This laſt I ſubjected to a red-heat for two hours, re-diſſolving it afterwards in hot water. Upon the filter there remained a ſubtle red-brown oxyd of iron, weighing nine grains, and wholly obeying the magnet.

f) The ſolution, now freed from the iron, afforded, by cryſtallization, a pure ſulphat of magneſia; which, when properly decompoſed by pot-aſh, and with the aſſiſtance of heat, yielded 133 grains of *carbonated magneſia*.

g) The ſulphat of lime (*d*), decompoſed by diſſolved carbonat of pot-aſh, furniſhed 160 grains of crude calcareous earth. To examine whether this laſt ſtill contained any magneſia, I diſſolved it again in nitric acid, mixed the ſolution with cauſtic ammoniac, and filtered the precipitate then formed. This immediately diſſolved in ſulphuric acid, which was added, and being precipitated by carbonated potaſh, it ſtill yielded three grains of magneſian earth; which ſubtracted, leaves, therefore, 157 grains for the quantity of crude calcareous earth, or *carbonat of lime.*

Conſequently, I obtained from the above 300 grains of the *Tyroleſe magneſian-ſpar:*

Carbonat of lime	g)		157 grs.
Magneſia	f)	133	136
	g)	3	
Oxyd of iron, containing ſome manganeſe	e)		9
			302 grs.

As no loſs of weight, but rather an exceſs, appears in the ſum of the conſtituent parts, given ſeparately, we may conclude, that thoſe ingredients might, perhaps, have been capable of undergoing a ſtill greater degree of deſiccation.

Therefore *a hundred* parts of *magneſian-ſpar* conſiſt of:

Carbonat of lime	52
Magneſia	45
Oxyd of iron, impregnated with mangameſe	3
	100

B.

Although it is only a few years ſince this foſſil was brought to Vienna by ſome Tyroleſe dealers in minerals of their country,[*] and from thence brought into farther notice; yet it ſeems that Woulfe has already been acquainted with it at an earlier period. For the foſſil, which he examined, and deſcribed in the *Philoſoph. Tranſ.* for 1779* by the name of *compound ſpar*, agrees with the Tyroleſe.

It is alſo proved, that the magneſian-ſpar is found not only on the borders of the Tyroleſe and Salzburg mountains, but likewiſe in other places, by the following examination of a ſpar of that kind, coming from *Taberg*, in *Wermeland*, a province of Sweden.

It occurs in the foſſil, in which I have found it of a grey-white colour, with a ſtrong luſtre, nearly reſembling that of the mother of pearl, in ſemi-pellucid and rhomboidal fragments. With regard to its fracture, it can hardly be diſtinguiſhed from that variety of the Tyroleſe magneſian-ſpar, which furniſhed the ſubject of the foregoing analyſis. The only difference conſiſts in its external form; that is, it does not occur in ſingle interſperſed cryſtals, like the laſt, but in maſſes; and it is accompanied by a green, compact, indurated clay, and a groſs-foliated, deep verdigris-green *talc* (magneſian earth.)

a) A ſmall piece of it, ignited *per ſe* upon charcoal, turns brown without ſplitting. It diſſolves, by fuſion, in a neutral phoſphat, and forms a clear, colourleſs bead. Nearly the ſame effect is produced by *glaſs of borax*. When heated to redneſs with ſoda on the melting-ſpoon, it fuſes into a dull, blueiſh-green globule.

b) *Two hundred* grains, reduced to powder, diſſolved gradually, and with effervescence, in the muriatic acid. Cauſtic ammoniac, added to the yellow ſolution, produced a light flocculent precipitate of a dirty green, which on the filtering paper changed to a brown, and, heated to redneſs, yielded 4½ grains of *oxyd of iron.*

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* *Kirwan's* Elements of Mineralogy, Lond. 1794. vol. i. p. 92.

c) The ſolution, now rendered colourleſs, was evaporated to a ſmaller compaſs, mixed with one third part of alkohol, and combined with as much ſulphuric acid as was neceſſary to precipitate the ſiliceous earth from the ſelenite or gypſum (*ſulphat of lime*), which was then ſeparated, and waſhed with a mixture of alkohol and water.

d) When the whole of the liquor had been again reduced by evaporation, I precipitated its magneſian earth, by means of carbonated pot-aſh, aſſiſted by a boiling heat. It did not prove to be as looſe as it ought to have been, and thus it ſhewed, that it was not yet pure. Hence, on the affuſion of ſulphuric acid upon this precipitate, more ſelenite was depoſited, which I added to the firſt. The ſolution, thus freed from it, then afforded pure ſulphat of magneſia (*Epſom-ſalt*), which, re-diſſolved and decompoſed in a boiling heat, by alkaline carbonat, afforded 50 grains of *carbonated magneſia.*

e) The ſelenite alſo was decompoſed, by boiling with water and carbonated pot-aſh. Thus I procured from it 146 grains of mild, or *carbonated calcareous earth.*

This *Swediſh* magneſian-ſpar, therefore, contains much leſs magneſia than the *Tyroleſe*; and the proportion of its conſtituent parts in one *hundred* is the following:

Carbonat of lime	73
Magneſia	25
Oxyd of iron, containing a little manganeſe . . .	2,25
	100,25

XXII.

XXII.

EXAMINATION

OF THE SUPPOSED

MURIACITE.

THE review of our preſent knowledge of mineral bodies would undoubtedly be much more extenſive, and at the ſame time require much fewer corrections, if every newly diſcovered foſſil were immediately put to the chemical teſt, and not received into the ſyſtematical arrangement, till it had been ſtamped with the authentic ſeal of truth.

The *muriacite* does not ſeem to be as yet ſo generally known, that I may not hope to be able to prevent its farther introduction to the public in an erroneous ſhape, by means of the examination which I am going to deſcribe.

*Fichtel** gives the following account of it.

Abbé Poda *has lately diſcovered a new ſpecies of calcareous earth, which, by reaſon of its conſtituent parts, he calls* muriated lime, or muriacite, *according to the new method of nominating foſſils; becauſe that mineral is compoſed of calcareous earth, muriatic acid, and water. The miners in the ſalt-pits at* Hall, *in* Tyrol, *call it* ſcaly gypſum (*ſchuppiger gyps-ſtein.*) *But, beſides this difference in its conſtituent parts, it is alſo farther diſtinguiſhed from the compact gypſum:* 1ſt, *by its greater hardneſs;* 2dly, *by the quadrilateral,*

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* See his *Mineralogiſche Aufsaetze.* Vienna, 1794, page 228.

rectangular ſcales or laminas, of which it is entirely compoſed; and 3dly, *by its much more difficult ſolution in water, of which, at a mean temperature, it requires* 4300 *parts. We expect to receive from the Abbé himſelf the circumſtantial deſcription of this new ſpecies of calcareous earth.*

This foſſil the more deſerved a chemical examination, as hereby we might be enabled to underſtand by what means Nature could produce a combination of the earthy ſaline kind, which in the dry as well as in the cryſtallized ſtate is ſo much diſpoſed to deliqueſcence; but which, as here is ſuppoſed, exiſts in a dry and compact ſtate, and at the ſame time requires ſuch an exceſſive quantity of water to be diſſolved.

That ſpecimen, which has been ſent me from *Vienna*, as *genuine muriacite* of *Hall*, in *Tyrol*, is an aggregate of rectangular, four-ſided plates, of a light-grey, black-grey, and in part reddiſh colour, with bright ſpecular ſurfaces; and hence not ill reſembing groſs-foliated hornblende. By the taſte, and partly even by bare inſpection, it betrays an admixture of ſome portion of rock-ſalt. Trituration reduces it to a white-grey powder.

a) Upon *five hundred* grains of it alkohol was poured; which, after 24 hours, I again ſeparated by filtering. The ardent ſpirit continued colourleſs; and when evaporated, it left pure common ſalt, or muriat of ſoda, behind, in the ſtate of dry cryſtals.

b) This being done, water was affuſed upon the powder, until all the ſaline parts were lixiviated. This aqueous ſolution, which was likewiſe colourleſs, being evaporated to dryneſs, left alſo *common ſalt* behind; but contaminated with *gypſum.*

c) The ſalt obtained in both extractions, and added together, weighed 91 grains. By the affuſion of *one* part of alkohol, mixed with three of water, all the ſalt was diſſolved, and the reſidual *gypſum* amounted to 17 grains. This determines the quantity of the *muriat of ſoda* at 74 grains.

d) I next treated the powder (which had been previouſly extracted both by alkohol and water) with dilute nitric acid; digeſting it gently. Carbonated pot-aſh, added to the nitrated fluid which was again ſeparated, threw down an earth, weighing 26 grains when dried, and conſiſting of *calcareous earth*, impregnated with iron.

e) The reſidue was boiled with water and carbonated pot-aſh. The fluid, filtered off, was then ſaturated with nitric acid. By the addition of muriated barytes, a precipitate was obtained, conſiſting of ſulphat of barytes.

f) Upon the edulcorated reſidue I poured again ſome nitric acid, which produced a great efferveſcence. After due digeſtion I ſeparated the fluid by filtration; and, while yet boiling, I combined it with alkali, by which treatment I obtained 76 grains of *carbonated lime.* But as this laſt had exiſted in the foſſil, in a ſtate of combination with the ſulphuric acid, mentioned at (*e*), we muſt only reckon 120 grains of gypſum, or *ſulphat of lime.*

g) What remained, after the extraction with nitric acid, weighed now 265 grains. It was a minute, light-grey, micaceous ſand.

In theſe 500 grains of the foſſil, therefore, have been found:

Muriat

Muriat of ſoda	*c*)		74
Gypſum	*c*)	17	137
	f)	120	
Carbonat of lime	*d*)		26
Sandy reſidue	*g*)		265
			502 grs.

Hence, the exiſtence of a *native muriat of lime* in the *concrete ſtate*, and alſo the name of *muriacite*, which has been given to it, are incompatible with this reſult.

XXIII.

XXIII.

EXAMINATION OF THE *NATIVE ALUM* *From Miſeno.*

THE alum cavern (*grotta di alume*) at the Cape *Miſeno*, near *Naples*, which, as it were, ſerves as a laboratory, where Nature alone, unaſſiſted by art, is conſtantly producing perfect alum, has been mentioned only by few of the Naturaliſts who have viſited that country. Profeſſor *Spallanzani** ſays of this remarkable grotto:—*Before the traveller reaches the promontory* Miſeno, *he meets with its harbour, which, there is no doubt, is likewiſe a crater; as it is ſurrounded on all ſides with eminences. Thoſe elevations conſiſt of tufas, and on one ſide of them, a little above the ſea, there is ſeen an aperture, made by art, which is called* grotta di Miſeno; *and where ſulphat of alumine* (alum) *continually effloreſces. This ſalt is not known by the natives, or at leaſt they pay no attention to it.*

The ſubject of the following analyſis has been a portion of the alum of *Miſeno*, collected on the ſpot itſelf, and given to me by that worthy naturaliſt, *John Hawkins*, Eſq.

All ſaline effloreſcences agree in this, that while they continue in the dry ſtate, they give no ſign of the cryſtalline figure, that is *peculiar* to each particular ſpecies of ſalt. They always appear of a fibrous form. For this reaſon,

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* Travels in the Two Sicilies, vol. i.

reaſon alſo, this effloreſced native alum does not preſent its appropriate octahedral form, but is found in ſmall, detached, and roundiſh accumulations, of very thin and ſhort fibres, poſſeſſed of a white colour, and ſilky luſtre, though in part intermingled with minute cryſtalline grains.

a) *One thouſand* grains of this native alum, diſſolved in 10 ounces of boiling water, left 120 grains of a yellowiſh-grey earth on the filtering paper.

b) The clear ſolution, when evaporated for the purpoſe of cryſtallization, gradually, and alone, afforded 470 grains of pure, clear alum, in octahedral cryſtals; although their formation had not been promoted by the addition of pot-aſh. At the ſame time 25 grains of *ſelenite* (gypſum) appeared.

c) Thoſe 470 grains of cryſtallized alum, re-diſſolved in water, were decompoſed, while yet boiling, by carbonated lime. After the ſeparation of the gypſum then generated, I evaporated the remaining fluid, along with the waſhings, to a ſmaller bulk, and freed it from the ſelenite, which ſtill continued to appear. It yielded 27 grains of *ſulphat of pot-aſh.*

d) After this, the remainder of the ſolution of the crude alum, that would no longer ſhoot into ſolid cryſtals, was inſpiſſated, by farther evaporation, to a grey-white, unctuous maſs; being but an imperfect ſulphat of alumine. This ſubſtance might, in the preſent caſe, be conſidered as a true *mineral butter* (*Bergbutter*). By affuſion of water it formed a ſomewhat turbid ſolution; and, by being then treated with a ſmall portion of pot-aſh, it yet afforded 290 grains of concrete *cryſtals of alum.*

e) The above 120 grains of earthy reſidue (*a*) were boiled with mild vegetable alkali and water. The filtered liquor was then ſaturated to exceſs with muriatic acid, and combined with muriated barytes. Upon which ſulphat of barytes fell down.

f) I now drenched in muriatic acid the reſidue, that had been boiled with alkali. This laſt, again ſeparated from it by the filter, was next ſaturated with carbonated pot-aſh. *Eleven* grains of a yellowiſh earth were then precipitated; which, upon cloſer examination, were found to conſiſt of two grains of *oxyd of iron*, and nine grains of *carbonated lime*; which laſt, together with that which had been indicated in combination with ſulphuric acid by the muriated barytes (*e*), amounted to 15 grains of *ſelenite*.

g) The final remainder, which had reſiſted the attack of the muriatic acid, weighed 92 grains, and was a ſandy earth, of a greeniſh-grey colour, meager, and harſh to the feel.

From 1000 lbs. therefore, of this rough, native *alum from Miſeno*, may be produced, barely by ſolution in water, and ſubſequent cryſtallization:

1) *Alum, provided by Nature herſelf with the requiſite quantity of pot-aſh* . . .	470
2) *Alum, whoſe cryſtallization is promoted by adding pot-aſh*	290
	760 lbs.

When, therefore, *Spallanzani* cenſured the natives for not knowing, or for diſregarding this natural product, which is ſo eaſily procured, and which, with ſo little expence, may be made a profitable article of commerce, he was not unſupported by reaſon. This alum of *Miſeno*, it ſhould ſeem, might be of the ſame good quality as that of *Tolfa*; as it can be rendered as free from iron as this laſt, and, as beſides, the proportion of ſulphated pot-aſh would not be greater in it than in the Roman alum.

This portion of ſulphat of pot-aſh, contained in the *alum* from *Miſeno*, occaſions the following queſtion; which indeed it will be ſtill difficult to anſwer at this time.—It is: As this grotto conſiſts merely of volcanic tufa, in which no vegetation takes place, whence does Nature procure the vegetable alkali, requiſite to the generation of the cryſtallizable alum?

Note. Another inſtance of the like daily production of *native alum* occurs at *Solfatara*, where it is procured, and refined after the manner deſcribed by Prof. *Breiſlak*. From the following paſſage of his: *Eſſais Mineralogiques ſur la Solfatare de Pouzzole*, Naples, 1792, page 157, it appears——*That it is upon the ground of the production of theſe ſaline efflorescences, the abundance and richneſs of which are equally ſurprizing, and, likewiſe, of the exceſſive promptitude of their re-production, that it has been reſolved on to eſtabliſh at Solfatara a manufacture of alum, which of late has been put in activity by Joſeph Brentano Cimaroli.*—In the fuller account of it, given page 231, according to which, the aluminous lixivium, by means of boiling, is brought to ſhoot into cryſtals in no longer time than 24 hours, there is no mention made of any artificial addition of pot-aſh. It is therefore probable, that the alum of *Solfatara*, like the above of *Miſeno*, is already by Nature provided with that portion of pot-aſh, which is neceſſary to the production of perfectly cryſtallized alum.

XXIV.

XXIV.

EXAMINATION

OF THE

NATIVE SALT-PETRE (Nitre),

From Molfetta.

THE diſcovery of the native ſalt-petre-mine, or of the *Pulo*, producing nitre at *Molfetta*, in *Apulia*, made by Abbé *Fortis*, in the year 1783, could not fail to attract the attention of naturaliſts, in a degree proportionate to the importance of the ſubject.

Various philoſophers, who have viſited and examined the *Pulo* ſince its diſcovery, have already given circumſtantial deſcriptions of the natural ſtate of that remarkable pit, as well as an account of the great quantity of nitre which it affords, and of its incomprehenſible daily re-production. As to theſe deſcriptions, I ſhall refer the reader chiefly to thoſe publiſhed by Prof. *Zimmermann* of *Brunſwick* *, and by *de Salis Marſchlin*'†.

The nitre employed in the following analytical experiments was collected by *John Hawkins*, *Eſq*, who has examined that nitre-pit in the *March* of 1788, in company

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* *Voyage à la Nitrière Naturelle, qui ſe trouve à Molfetta*, par M. *Zimmerman*. Paris, 1789.

† *Reiſen in Verschiedene Provinzen des Königreichs Neapel.* 1ſt vol. Zuric and Leipzig.

with *Zimmermann* and *Fortis.* In the ſpecimens which I was favoured with, the ſalt-petre inveſted fragments of a yellowiſh-white, compact, lime-ſtone, forming the ſtony matter of the *Pulo.* Theſe fragments, detached from the rock in thin layers, are incruſted with the ſalt, to the thickneſs, for the moſt part, of one ſixth of an inch; when it appears in a finely-grained, cryſtalline form, reſembling white refined, or Canary ſugar. On ſome parts of the lime-ſtone I diſcovered thin incruſtations of a finely-fibrous gypſum, which, in ſome places, ſerved as a baſe for the nitre to reſt on.

a) *One Thouſand* grains of this native ſalt-petre, together with the lime-ſtone and gypſum to which it adhered, were covered with boiling water. The remaining lumps of ſtone having been lixiviated, the clear and colourleſs ſolution, thus obtained, was next prepared for cryſtallizing by gentle evaporation. Each ſhooting of the ſalt was accompanied by tender, needle-ſhaped, ſelenitic cryſtals. No *mother-water* remained: but the whole of the ſolution cryſtallized, to the laſt drop, to a perfect priſmatic nitre. The ſelenite, ſeparated from the ſalt as much as was poſſible, weighed 40 grains; whereas the ſalt gave 446 grains.

b) According to reſearches of Profeſſor *Vairo**, this nitre is ſaid to contain common, or ſea-ſalt, in the proportion of 1 to 6. I therefore expected to obtain, beſides the priſmatic cryſtals of the ſalt-petre, ſome ſea-ſalt alſo, in diſtinct, ſolitary cubes: but no trace of it, viſible to the eye, appeared. For this reaſon, I attempted to diſcover its preſence by another method. With this view, I re-diſſolved, in water, the cryſtals of nitre which I had obtained, and dropped diſſolved acetite of barytes into the ſolution. By theſe means I obtained a precipitate, conſiſting of 26 grains of ſulphated barytes; which ſhewed, that 18½ grains of ſelenite were ſtill united with the neutral ſalt. When, after this, I tried the nitrous ſolution with muriated ſilver, no more than 4½ grains of hornſilver (*muriat of ſilver*) would precipitate, ſo that the quantity of common ſalt, indicated by this laſt, can be eſtimated at only two grains. By this, the true quantity of perfectly pure nitre has been reduced to 425½ grains.

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* *Voyage à la Nitrière Natur. Zimmerman,* page 35.

However, I think it more probable, that the neutral muriat, which was mixed with the native nitre, was not muriated ſoda, but a *muriat of pot-aſh*, or digeſtive ſalt, as it is called.

c) Upon the ſtony ſubſtances remaining after the lixiviation of the crude nitre, and which exactly conſtituted one half of the firſt weight, viz. 500 grains, I poured muriatic acid. The pieces of lime-ſtone diſſolved with great effervefcence; leaving a reſidue of 196 grains behind, which were white gypſum, of delicate fibres. When the ſulphuric acid had been ſeparated from this laſt, by boiling it in water with carbonated pot-aſh, there remanied ſome carbonat of lime, which diſſolved, without any reſidue, in nitric acid.

The *lime-ſtone*, taken up by the muriatic acid, conſequently amounted to 304 grains; and, being ſubjected to farther trial, it proved to be merely calcareous earth, containing a ſmall portion of iron.

Hence, theſe 1000 grains of *nitre from Miſeno*, here decompoſed, have conſiſted of:

Pure

Pure priſmatic nitre .	*b*)	. . . .	425½ grains.
Muriated neutral ſalt .	*b*)	. . . .	2
Selenite	*a*)	40	254½
	b)	18½	
	c)	196	
Lime-ſtone	*c*)	. . .	304
			986
		Loſs .	14
			1000

By the computation of Prof. *Vaire*[*], the total maſs of ſalt-petre in the *Pulo* ſhould amount to between 30 and 40 thouſand centners, at 100 lb. each; and the ſecond reproduction of it to more than 50 thouſand centners. As, therefore, the alkaline baſe of priſmatic nitre conſtitutes nearly one half of the whole of that compound, it is obvious, that the queſtion which I have intimated at the cloſe of my laſt eſſay, concerning the origin of the vaſt quantity of vegetable alkali, becomes, in the preſent caſe, far more important and intereſting to the naturaliſt. The conjecture, that Nature poſſeſſes means of producing that alkali beyond the limits of the vegetable kingdom, nay, even without any immediate influence of vegetation, acquires, by this ſingular phenomenon, a very high degree of probability.

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[*] Loco Citato. Page 37.

XXV.

CHEMICAL EXAMINATION

OF THE

MINERAL SPRINGS, at Carlsbad.

AMONG the hot mineral ſprings of Germany, that at *Carlsbad*, in *Bohemia*, deſerves the particular attention, not only of the phyſician and the philoſopher, but alſo of every individual that has a due ſenſe of the grand ſcenes in nature.

The baſon of the main-ſpring, that wonderful reſervoir, is, perhaps, the only one of its kind, which Nature herſelf has formed of the conſtituent parts of the ſpring, and, at the ſame time, has covered it by a triple marble-vault, fitted for the collection of the mineral waters produced in the neighbouring ſubterraneous laboratory. The boiling main-ſpring, ruſhing, with vehemence, out of the principal apertures of this water-vault, and filling the atmoſphere with vaporous clouds;—the inceſſant play of the air-bubbles, forcing their way through the ſmaller rifts and fiſſures, and riſing in the form of pearls through the river Töpel, which flows immediately upon a conſiderable part of that vaulted roof of the ſpring:—all this, at the firſt view, invites the mind to reflection; at which the ſpectator can hardly avoid falling into the pleaſing illuſion of ſeeing Nature, that uſually likes to operate in a hidden manner, working here cloſe at hand, and, as it were, before his eyes.

I think it needleſs to enter into a topographical and phyſical deſcription of *Carlsbad*; becauſe there already exiſt ſeveral accounts and deſcriptions of it. Among theſe, the *Treatiſe on Carlsbad*, by Dr. *Becher*, may be conſidered as the moſt capital work. I ſhall, therefore, ſuppoſe the reader acquainted with its contents; which, alſo, in general, I refer to in this eſſay.

My principal deſign is, to ſtate our obſervations, and the conſtituent parts of the Carlsbad-water, the decompoſition of which we attempted* at the ſpot itſelf, in July 1789; as well as to compare them with thoſe given by Dr. *Becher*. Beſides this, I alſo intend to ſay ſomething of the manner which Nature, probably, adopts, in elaborating this mineral ſpring, by way of a ſmall addition to the theories that have been already offered on this head.

In our reſearches, we confined our experiments to the three principal ſprings: the main-ſpring, the *new ſpring*, and that in the *caſtle*. Upon the whole, theſe, like the other collateral ſprings that are leſs made uſe of, agree with each other in their conſtituent parts, as well as in the proportion of the more fixed parts, which, in all of them, is much the ſame. But they differ conſiderably from each other in their ſhare of carbonic acid; and this variation is regulated by the temperature, which in one ſpring exceeds that of another; the quantity of carbonic acid being in the inverſe ratio of that of the heat. And for this reaſon, of the above-mentioned three ſprings, main-ſpring the hotteſt of all, and whoſe temperature, upon an average, is of 165° of Farenheit's thermometer, contains the leaſt of the acid.

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* For I had the pleaſure of making theſe experiments in company with *Count Geſsler, Chamberlain and Privy-counſellor to the King of Pruſſia.*

The ſpring at the caſtle, on the contrary, the temperature of which is raiſed only to 120° or 125° *Farenh.* contains the greateſt portion of carbonic acid*.

To ſave the trouble of a tedious enumeration of the experiments made, I ſhall give only a ſhort deſcription of our method of proceeding, and mention the reſults in a ſummary way.

The conſtituent parts of the mineral-water of Carlsbad are, in general, *carbonat of ſoda*, *ſulphat of ſoda*, (Glauber-ſalt), and *muriat of ſoda*, or common ſalt; beſides theſe, *carbonated lime*, *ſiliceous earth*, and a ſlight trace of *oxyd of iron*: and, laſtly, a proportionate quantity of free, carbonic acid, or, to characterize it more preciſely, of *carbonic acid gas*, ſolely abſorbed by the water; beſides *free caloric.*

On attempting to ſeparate and to catch or obtain the carbonic acid gas, we proceeded in the following manner:—A glaſs-retort, of 23 cubic inches capacity, was filled with 18 cubic inches of water, taken from the pipe of the ſpring-head; and we lodged it immediately in the ſand-pot of a pneumatic diſtilling apparatus, purpoſely placed near that ſpring. The firſt receiver, into which the neck of the retort was inſerted, and the glaſs-cylinder employed to collect the extricating gas, had been filled with hot-water from the ſpring.

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* When we viſited *Carlsbad* a ſecond time in July 1793, we found the temperature of the

Atmoſphere	20	Degrees, Reaumur.
Spring at the caſtle . .	37½	
New-ſpring	48	
Liebschen-ſpring . .	55	
Main-ſpring	55½	

ſpring. Under theſe circumſtances, we expected that the gas would immediately diſengage itſelf, and paſs over, at the very firſt action of the heat on the retort; this, however, happened only a little before the commencement of actual boiling; which laſt we continued until no more air-bubbles came over.

The air collected in the cylinder amounted to 10¼ cubic inches. When, therefore, the five cubic inches of atmoſpheric air, that remained in the retort before the operation, are ſubtracted, the portion of gas, diſengaged from 18 cubic inches of Carlsbad-water, at the main-ſpring, conſiſts of 5¼ cubic-inches. Theſe were entirely abſorbed by lime-water, and a calcareous precipitate was produced; ſo that nothing remained but the five cubic-inches of atmoſpheric air. By this, and by ſeveral other trials, we were convinced that the gas, diſengaged by that mineral water, conſiſts of pure *carbonic acid*; that the ſulphurated hydrogen gas, which various authors have ſuppoſed to exiſt in it, along with the carbonic acid, is never preſent; and that the preſence of *ſulphureous acid*, together with uncombined ſoda, as ſome others have imagined, is not even ſo much as poſſible.

By the ſame management, and under the ſame circumſtances, an equal quantity of the water of the *new-ſpring* afforded nine cubic inches, and of the *ſpring at the caſtle* 9½ cubic inches, of carbonic acid gas.

I will allow that, by this method of collecting and meaſuring the carbonic acid gas, the higheſt degree of accuracy was not, perhaps, ſo certainly obtained as it would have been by properly employing the pneumatic quickſilver apparatus, which, at that time, was not in our power at Carlsbad. Nevertheleſs, I am convinced that this method, of conducting and collecting the diſengaged gas, through and by means of the hot water of the main-ſpring, inſtead of employing mercury for that purpoſe, cannot have occaſioned any conſiderable difference in the reſult: for water, in general, when of equal temperature with the natural warmth of the Carlsbad main-ſpring, is not capable of abſorbing a notable portion of carbonic acid. And, beſides, ſuch an abſorption of that acid gas could the leſs have taken place in the preſent inſtance, as that water, being naturally impregnated with as much carbonic acid as it can contain, was incapable of taking up an additional quantity of that acid.

If this proportion of carbonic acid, found in the above-mentioned three ſprings at Carlsbad, be compared with that given by Dr. *Becher*, which, calculated to eighteen cubic inches of water, would amount to ſeven cubic inches in the main-ſpring, to $6\frac{1}{3}$ in the new-ſpring, and to 10 in that at the caſtle, there, indeed, occurs a difference; ſince, in our experiments, the carbonic acid extricated from 18 cubic inches of the main-ſpring water meaſured $1\frac{1}{4}$ cubic inch, and from that at the caſtle $\frac{1}{2}$ inch leſs than Dr. Becher's reſults, whereas that obtained from the water of the new ſpring, meaſured $2\frac{1}{3}$ cubic inches more.

But as Dr. *Becher* had the opportunity of employing a quickſilver-apparatus, and as, therefore, I have the leſs reaſon to doubt the exactneſs of his experiments, we are, from thence, the more confirmed in the ſuppoſition, that the proportion of the conſtituent parts of mineral waters is not every year, and, perhaps, not every day and hour exactly the ſame, but rather variable. This fact is alſo proved by other phenomena and arguments.

The water of Carlsbad, likewiſe, contains ſome *iron*, the preſence of which can be aſcertained only at the ſpring itſelf; ſince

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ſince the quantity which actually exiſts in that fluid is ſo exceedingly ſmall as to eſcape, in a moſt rapid and unexpected manner, the ſenſes as well as the efficacy of re-agents. And, for this reaſon, many perſons have abſolutely doubted the preſence of diſſolved iron in theſe ſprings. But that they contain it, Dr. *Becher* has demonſtrated by the following experiment. He ſuſpended, by a thread, one half of a nut-gall in a glaſs bottle of a narrow neck, and filled the veſſel on the very ſpot with water of the main-ſpring As ſoon as the water, in the action of filling, came in contact with the nut-gall, it acquired a reddiſh colour; but five minutes after, the colour changed to a bright-red, inclining to the violet.

We, likewiſe, made the ſame experiment. Having previouſly ſuſpended a ſlice of a gall, by means of a white ſilk thread, in a glaſs-bottle, of 50 cubic inches capacity, we filled it at the main ſpring. The water inſtantaneouſly turned of a pale red; but after having ſtood at reſt, for one hour, a purple-red, extremely light, woolly, flocculent ſediment ſubſided, which left the ſuperincumbent liquor clear and colourleſs.

Another bottle, in which one grain of pulverized pure Pruſſian alkali had been placed, when likewiſe filled at the ſpring itſelf, ſhewed no change or indication of colour. But ſome minutes after, when we inſtilled ſome drops of nitric acid to ſaturate the predominant ſoda, the blue colour appeared by degrees; ſo that, at length, the water was uniformly tinged blue by it.

The following experiments convinced us, how neceſſary it is to perform theſe trials at the ſpring itſelf. We had ordered a jug, recently filled, at the main-ſpring, and cloſely ſtopped, to be brought to our lodgings; where we immedi-

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ately, and before the temperature of the water had been ſenſibly lowered, examined it by means of galls, and tincture of galls. But it remained for a while colourleſs; only, by degrees, it inclined a little to a feeble, turbid olive-green; and when afterwards a few drops of nitric acid had been added, the colour paſſed into a ſhade of a dilute blueiſh-black.

But when the water from the main-ſpring had cooled more conſiderably, it was no more poſſible to produce, by any means, any change of colour, or indication of iron.

The water of the *new ſpring* afforded the ſame phenomena as that of the main-ſpring; that is to ſay, when the bottle, into which the re-agents had been previouſly introduced, was filled at the ſpring itſelf, the water became coloured, and ſhewed its ferruginous contents. But when conveyed to our apartment, in well cloſed bottles, it was tinged in ſome degree, while its original temperature continued; but as ſoon as the water began to cool, no trace of colour could then be any longer diſcovered.

On the contrary, the water from the *ſpring at the caſtle*, though likewiſe taken at the ſpring itſelf, and there examined, ſuffered no change at all.

It now remained to inveſtigate the other *fixed* conſtituent parts: for this purpoſe, we gradually evaporated, with a gentle heat, *one hundred* cubic inches of water, freſhly taken from each of thoſe three ſprings, down to ſome ounces.

We then ſeparated, by means of filtration, from theſe reſidues, thus reduced by evaporation, the *earthy* parts from the *ſaline*, that were yet held in ſolution by the water, and waſhed and dried them. This earthly portion conſiſted of *carbonated lime*, mixed with *ſiliceous earth*, and a ſlight trace of *iron*. By digeſting it with muriatic acid, the lime and the iron diſſolved, and, on the filter, we obtained the ſilex alone, in a looſe, ſlimy ſtate. The muriatic ſolution we treated, at firſt, with pruſſiat of pot-aſh, and there immediately appeared blue flocculent particles: however, it was only after ſome days that they formed a ſolid precipitate. When the ſupernatant liquors had again become clear and colourleſs, and the precipitate had been ſeparated upon the filter, we precipitated the calcareous earth from each of them by carbonated ammoniac, edulcorated, and dried it.

We now proceeded to ſeparate the ſalts combined in thoſe ſolutions. Taught by experience, that heterogeneous ſalts, exiſting in one common menſtruum, can but ſeldom be ſeparated, by cryſtallization, with due accuracy, eſpecially in ſmall experiments, we adopted another more certain method; namely, by ſaturating, firſt, the uncombined ſoda by an acid, and decompoſing afterwards the neutral ſalts by proper ſubſtances. At the ſame time, by other previous experiments, we had diſcovered and aſcertained the proportions of the ingredients in ſalts of the ſame nature, to be enabled thereby to calculate thoſe reſults.

Theſe laſt mentioned experiments, ſerving as ſtandard meaſures in the preſent purſuit, were principally as follows.

a) Thouſand grains of ſoda, recently cryſtallized and weighed, after drying on printing-paper, loſt, when completely deſiccated on the ſand-bath, 637 grains of weight. Thouſand parts of ſoda in the ſtate of cryſtallization, therefore, are equal to 363 parts of the ſame alkali, reduced to a powder by a thorough exſiccation effected by means of heat.

b) Hundred grains of the ſame ſoda, deprived by heat of its water of cryſtallization, required, for their ſaturation, 382 grains of ſulphuric acid, compoſed of a mixture of one part of that acid, rectified, and of 1,850 ſpecific gravity, with three parts of diſtilled water.

c) The ſulphat of ſoda, obtained by this ſaturation, and completely dried, by evaporating in a ſand heat, weighed 132½ grains.

d) One *thouſand* grains of ſulphat of ſoda, recently cryſtallized and dried on printing-paper, when exſiccated to the moſt in a ſand-heat, weighed 420 grains.

e) *Hundred* grainsof the above-mentioned glauber-ſalt, diſſolved in water, and decompoſed by an acetic ſolution of barytes, gave 168 grains of waſhed and dried ſulphat of barytes, or regenerated ponderous ſpar. Thouſand parts of the latter, therefore, contain a portion of *ſulphuric acid* equal to 595¼ of ſulphated ſoda, that has been deprived by heat of its water of cryſtalliſation.

f) One *hundred* grains of common ſalt in cryſtals, dried in the air, diſſolved in water, and decompoſed by a nitric ſolution of ſilver, yielded 233½ grains of edulcorated and dried muriat of ſilver, or precipitated hornſilver, as it is called. Whence the quantity of muriatic acid, contained in 1000 parts of this laſt, is equal to 428¼ parts of pure and dry muriat of ſoda.

Aſſiſted by theſe diſcoveries, we could now, with certainty, expect the ſucceſs of our attempt without danger of error, by making a proper uſe of them. Thus we firſt inveſtigated the quantity of free or *carbonated ſoda*, by adding to every one of thoſe ſolutions as much of an accurately weighed quantity of ſulphuric acid, of the ſpecific gravity mentioned, (*b*) as was neceſſary to a complete ſaturation, and from the portions of the acid employed in theſe proceſſes, we computed the quantity of the alkali contained in each of the ſolutions.

. . . . . .

This done, we combined the muriatic ſolutions with diſſolved acetate of barytes, until all precipitation ceaſed. From the weight of the *barytic ſulphat* then generated, we calculated the quantity of ſulphated ſoda: having, before, ſubtracted that portion of it, which had been produced by the ſaturation of the uncombined ſoda, and united with the glauber-ſalt, naturally contained in the ſpring.

At laſt, we decompoſed the common ſalt, left in the ſolutions after the ſeparation of the barytic ſulphat, by means of a nitrated ſolution of ſilver; and we computed the quantity of that muriated ſoda from the hornſilver, obtained by the proceſs.

It reſulted from theſe experiments, that

A) *Hundred* cubic inches of water from the *main-ſpring*, at Carlsbad, contain:

Dry carbonated ſoda	39 grains.
(or, in cryſtalline ſtate, 107½ gr.)	
Dry native ſulphat of ſoda	70½
(or, in cryſtals, 168 gr.)	
Muriat of ſoda	34⅝
Carbonat of lime	12
Silex	2½
Oxyd of iron, about	⅛
Total . .	158¾ gr.

Carbonic acid gas, 32 cubic inches.

B)

B) *Hundred* cubic inches of the water, taken from the *new-ſpring*, contain:

Dry Carbonat of ſoda	38½ grains.
(or, cryſtallized, 106·gr.)	
Dry native ſulphated ſoda	66¾
(or, cryſtallized, 159 gr.)	
Muriat of ſoda	32½
Carbonat of lime	12⅛
Siliceous earth	2¼
Oxyd of iron, hardly	⅛
Total . .	152⅛ grains.

Carbonic acid gas, 50 cubic inches.

C) And laſtly, an *hundred* cubic inches of water from the *ſpring at the caſtle* yielded,

Dry corbonat of ſoda	37½ grains.
(or, in cryſtals, 103½ gr.)	
Dry ſulphated ſoda	66½
(or, in cryſtals, 158⅓ gr.)	
Muriat of ſoda	33
Carbonat of Lime	12¾
Silex	2⅛
Oxyd of iron, hardly	1/16
Total . .	151 15/16 grains.

Carbonic acid gas, 53 cubic inches.

In order to enable any perſon to reduce theſe conſtituent parts to certain weights, or to other liquid meaſures of the mineral water, I will mention, that the cubic inch, which, in theſe experiments, has been made the ſtandard, is equivalent to 290 grains of diſtilled water, (of the genuine medicinal weight of Nurenberg *). The above 100 cubic inches, therefore, with reſpect to their ſolid capacity, are equal to $60\frac{5}{12}$ ounces of water.

On comparing the fixed conſtituent parts, diſcovered by Count *Geſsler* and *myſelf*, with thoſe given by Dr. *Becher*, I ſhall notice merely the water of the main-ſpring. The quantity of it, which he employed, in every inſtance, was ſix pounds medicinal weight. Dr. *Becher* obſerves, that he means the old apothecary's weight and meaſures, formerly uſed there; which is, to that now introduced, as 12 to 14; but I ſuppoſe that the above is the ſame with the uſual medicinal weight, of 12 ounces, or 5760 grains. Therefore, by calculating, according to theſe data, the dry reſidue which we ſhould have obtained from 6 lb. medicinal weight, or from $119\frac{5}{29}$ cubic inches of water from the main-ſpring, would have amounted to $189\frac{27}{143}$ grains; and this very nearly agrees with the 192 grains obtained by Dr. B.; the difference of $2\frac{116}{143}$ being very unimportant, eſpecially as he himſelf has alſo obtained three drachms, or 180 grains leſs of this dry reſidue from an equal quantity of the main-ſpring water. With regard to the *proportion* of the fixed parts to one another, Dr. *Becher* thinks that the ſeveral conſtituent ingredients, in thoſe 192 grains, may be divided in the following manner:

Dry ſoda	53 grains.
—— *Sulphat of ſoda*	93
Muriat of ſoaa	26
Calcareous earth	$20\frac{1}{2}$

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* Or $278\frac{1}{4}$ grains, *Engliſh Troy*, very nearly. Tranſl.

But, according to the reſult of our experiments, the above-mentioned 192 grains of the reſidue of the water from the main-ſpring would afford,

Dried ſoda	47¼ grains.
—— *Sulphat of ſoda.*	85¼
Muriat of ſoda	42
Calcareous earth	14½
Siliceous earth	3

To explain theſe variations, beſides firſt repeating the obſervation before mentioned, that in mineral waters the proportion of the ingredients is not, at all times, invariably the ſame, I believe the following remark may be of ſome aſſiſtance in elucidating the difference.

a) Dr. *Becher* procured the *ſoda*, which he uſed in his preparatory experiment, by diſſolving, in water, the calcined reſidue of the deſiccated mother-water; and, having cryſtallized it, he conſidered the ſalt obtained, at the third ſhooting, as pure mineral alkali, and employed it accordingly. This, however, cannot eaſily be preſumed to have been perfectly pure, but was probably ſtill mixed with ſome common ſalt; which ſuppoſition ſeems to be ſtrengthened by the figure of the cryſtals, deſcribed as minute-grained and needle-ſhaped. On every account it would, indeed, have been not ſuperfluous to have tried, before-hand, by experiments, the purity of the ſoda, and the total abſence of all neutral ſaline admixtures. For, in proportion as the ſoda employed in the comparative experiment was ſtill rendered impure, by any foreign ſalt, in the ſame ratio muſt the calculation, founded upon it, have given an exceſs of ſoda above the true quantity which enters into the water of the ſpring.

b) That the portion of *common ſalt* was found to be much leſs by Dr. *Becher*, than by us, ariſes from the uncertain method which he has employed to ſeparate the ſulphat and muriat of ſoda, by mere cryſtallization; ſince the former, eſpecially in the laſt ſhootings, always attracts to itſelf a portion of the latter, which accompanies it in the lye. Therefore,

c) The proportion of the *neutral ſulphat* of the ſpring, as determined by calculation, muſt, for the ſame reaſon, have appeared greater than it really is.

d) The *ſiliceous* ingredient in the water of Carlsbad has entirely eſcaped the attention of Dr. *Becher*, as it did other authors, who treat of this ſpring. This, however, may be excuſed, becauſe ſilex has been formerly conſidered as a ſubſtance totally inſoluble in water, and, therefore, has never been ſuſpected to be a conſtituent part of mineral ſprings. But it cannot be allowed that this earth is only caſually admixed with the water, and floats in it as a fine ſand; for, that it exiſts in it in an actual ſtate of ſolution, is evident, from the ſwelled, ſlimy, and tranſparent ſtate in which it remains after the ſolution of the calcareous earth.

Nevertheleſs, this quantity of ſiliceous earth, in Carlsbad water, whoſe ſolvent power over this earth is aided by its temperature, great as it may appear, with regard to other mineral ſprings, is, in fact, but inconſiderable, when compared with the ſilex, contained in a much larger portion, in other hot-ſprings; the *Geyſer*, for inſtance, in *Iceland*. But it muſt alſo be obſerved, that the temperature of this laſt ſo far exceeds that of Carlsbad, that, according to *Troil's* teſtimony, even when this immenſe jet of 19 feet in diameter had riſen, as it often does, to the height of 90 feet, its water is ſtill found perfectly boiling hot, when it again comes down to the ground.

I ſhall now give an eſtimate of the quantities of the conſtituent parts of the water of Carlsbad, taken by its viſitors. The mean number of cups which are drank is 14 in the day, as the daily allowance is from 10 to 18; the immoderate quantity of 30 or 40 cups, and upwards, which were formerly taken, being now laid aſide: one of theſe cups, upon an average, holds nearly 10 cubic inches of water; and, therefore, will hold 140 cubic inches, which contain:

Cryſtallized carbonated ſoda	150½ grains.
——— *Sulphat of ſoda*	228
Muriat of ſoda	48
Calcareous earth	17⅓
Siliceous earth	3½
Oxyd of iron	¼

Carbonic acid gas, 45 cubic inches.

The time uſually ſpent in the medicinal uſe of this ſpring is from three to five weeks. If, therefore, we aſſume, at a mean rate, 26 days for the whole of that time, and calculate by it the quantity of water drank by each patient, it will be found to amount to 364 cups, holding 3640 cubic inches of the mineral water, which contain,

Cryſtallized carbonat of ſoda	3913 grains.
——— *ſulphat of ſoda*	5928
Muriated ſoda	1248
Calcareous earth	450
Siliceous earth	91
Oxyd of iron	6½

Carbonic acid gas, 1170 cubic inches.

It is not my province to ſpeak of the medicinal effects of the mineral ſpring at Carlsbad. On this ſubject various celebrated phyſicians and writers, as *Fred. Hoffmann*, *Tralles*, *Springsfeld*, *Zückert*, and in particular Dr. *Becher*, the reſpectable author of the above-mentioned *Deſcription of Carlsbad*, have given ſufficient information and inſtruction.

On one point, however, I ſhall briefly touch. Many perſons, leſs verſed in chemiſtry, are of opinion, that the native glauber-ſalt of this mineral ſpring is eſſentially different from, and preferable to any other ſulphat of ſoda; upon the ground, that a moderate quantity of the water, for inſtance 14 cups, in which that neutral ſalt, calculated in the cryſtalline ſtate, amounts only to 228 grains, or 12 grains leſs than half an ounce, is found to poſſeſs a greater aperient power than any other artificial glauber-ſalt, though taken in greater proportion. But in this ſtatement, which is confirmed by experience, we ſhould not forget to have due regard to the influence of the ſoda; becauſe the alkaline ſubſtances and earths are converted into neutral or middle ſalts, in the ſtomach and firſt paſſages, whenever, as is moſtly the caſe, any acid there predominates, and they thus acquire the cathartic properties of other purging ſalts. Nay, it is probable that it is owing to this conſtituent part of the Carlsbad water that ſeveral perſons, whoſe humours in the ſtomach and firſt paſſages are, perhaps, more diſpoſed to *alkaleſcence* than *acidity*, often experience, on its internal uſe, effects quite contrary to thoſe which they expected from its opening power. Moreover, the ſiliceous ingredient may be frequently an acceſſory cauſe of the unpleaſant effects on the bowels, which the water produces in thoſe perſons in whom the *periſtaltic motion* is rather languid.

However, theſe, as well as all other medical remarks, I leave to the phyſicians, and will allow to myſelf only ſome reflections concerning the ſubſtances, which Nature employs to impregnate the Carlsbad mineral ſpring with the above-mentioned ingredients, and concerning the manner in which, perhaps, it operates in this proceſs. I ſay, *perhaps*, for the ſearching mind of man is not endowed with the faculty of inſpecting the interior and ſecret receſſes of the laboratory of Nature, without danger of error. All that we are able to do, is to ſuſpect, and to draw probable conjectures from phenomena ſimilar to thoſe, which we have had opportunity of perceiving either in the operations of Nature herſelf, or in our ſmall chemical experiments.

The cauſe which produces the heat in the ſprings at Carlsbad is variouſly ſtated by philoſophers. The opinion of a great fire, ſuppoſed to exiſt in the centre of the globe, to which, formerly, all the great phenomena in the ſubterraneous laboratory of Nature, and hence alſo the generation of hot mineral ſprings, have been aſcribed, has, at preſent, ſcarcely any ſupporter. Others would account for that cauſe by the volcanos, which are ſaid to have once exiſted in that country, and, though burned out on the ſurface, are not yet perfectly extinguiſhed beneath. But this, likewiſe, is an ill-founded hypotheſis; as neither a true crater, nor what might have once been the fire-gulph of a volcano, nor any undoubted lavas and other matters ejected from it, can be found there. In fact, the earthy ſcoriæ, met with in the vicinity of Carlsbad are not of a true volcanic origin; and as little may the baſalts, which are there met with, be conſidered as an additional proof of the volcanic nature of that country.

Thoſe naturaliſts ſeem to come nearer to truth, who trace the efficient cauſe of heat in theſe ſprings from ignited ſulphur-pyrites. With this opinion, likewiſe, the celebrated author of the Treatiſe on Carlsbad Water coincides, when explaining the temperature of its ſprings. And, indeed, it cannot be denied, that pyrites act their part in this caſe.

For the ſtratum of pyrites, which is only a few miles diſtant from Carlsbad, and from which the ſulphur and vitriol-works at *Altsattel* are plentifully provided with that crude material; beſides, the ſiliceous ingredient diſſeminated in the ſtony mixture of that ſtratum, under which, according to all indications, that ſubterraneous laboratory lies where Nature prepares the mineral water; and, laſtly, thoſe conſtituent parts of theſe mineral ſprings, the origin of which we cannot explain from other ſubſtances beſides from ſulphur-pyrites: all theſe circumſtances coincide to give weight to that opinion.

Yet, on a maturer conſideration, it will ſoon be evident, that the diſſolved pyrites could not alone afford that quantity of caloric, which has heated the ſprings at Carlsbad, for ſeveral centuries paſt to this day, with unabated force; but, on the contrary, that, to the production and preſervation of natural hot ſprings in general, another combuſtible matter is required, from which the ſubterraneous fire receives its food. And thus it will be obvious, that this fuel can be nothing elſe but mineral coal, that remainder of vegetable fragments of the ancient world, locked up in the boſom of the earth, which provident Nature has wiſely reſerved.

When a ſubterraneous ſtore of mineral coal, ſuch as occur in various places in ſtrata, of an enormous thickneſs, has been once ſet on fire, by ignited pyrites or other cauſes (as may eaſily happen, eſpecially where the ſtratum comes out near to the day) the inflammation will then ſpread throughout the whole remaining maſs, with a quicker or ſlower progreſs. A ſpontaneous extinction and complete refrigeration can certainly not be very ſoon expected in that caſe; for the larger the bulk of a burning body is, the longer will the heat, excited by it, continue. If, beſides, it is conſidered, that this immenſe maſs may poſſibly be incloſed by walls of rocks, impenetrable, and little capable of conducting heat, at the ſame time that the air finds acceſs to it in but a very ſmall degree; it is then eaſy to conceive, that ages muſt paſs before the caloric diſengaged from ſuch an immenſe maſs can be fixed again, and brought to a ſtate of equilibrium with the whole.

But that a mine of mineral coal had once been burning at Carlsbad is a fact, unqueſtionably proved by the earthy ſcoriæ that have been erroneouſly taken for genuine volcanic lavas, by the porcelain-jaſpers, and by the other ſpecies of ſtones and earths, more or leſs changed by fire, covering the fields at *Hobdorf*, *Leſſa*, and other places, in copious quantity, many of which perfectly reſemble the pſeudo-volcanic products of various countries; ſuch, for inſtance, as the ſtratum of mineral coal even now burning at *Duttweiler*, near *Saarbrück*.

Carlsbad, which is ſituated in a narrow, longiſh valley, is on all ſides ſurrounded by mountains of the middle ſize; which, however, little cohere among themſelves. Theſe moſtly conſiſt of granites, of which that variety is the moſt predominant, which conſiſts of much, large, yellowiſh, white rhomboic fel-ſpar, with ſmall black micaceous ſcales, and a little fine grained quarz.

But, cloſe to the *Hirſchenſtein*, the higheſt of thoſe mountains, and ſituated ſouth of the town, there ſtretches from the *Guildhall* to the *Bernhards-rock* another range of low mountains, which cannot properly be conſidered as primitive granite, but rather as a rock of later formation: ſince it exhibits a ſtony maſs, a ſecond time formed of fragments of the primeval rock, and conſiſting of a granitic maſs of ſtones, finely grained and rifty, paſſing into a porphyraceous mixture, with finely interſperſed pyrites. It is the common opinion, which is alſo ſupported by various local circumſtances, that underneath this mountainous range, the laboratory lies, where Nature produces that beneficial ſpring. For, not only does the vaulted roof of the baſon, or reſervoir of the main-ſpring, (the breadth of which extends from the Guildhall, along and under the market-place, as well as under the bed of the river *Töpel*, to the church) proceed from the foot of that low rock, but alſo all the other ſprings iſſue from it; beſides, that the warm mineral water oozes out from ſeveral other of its fiſſures and veins. But, if this ſtony matter is granted to be of ſecondary formation, and not a primitive rock, the poſſibility of a mighty ſtratum of mineral coal, lying under it, can no longer be queſtioned.

Now, concerning the generation and origin of thoſe conſtituent parts, with which this hot water is impregnated, and thereby ennobled to the rank of a medicinal ſpring; theſe depend on the *very ſame laws of nature*, which chemiſtry has learnt by experiments to be ſuch, and by which it is guided in imitating the operations of Nature in the ſmall way. Yet, our knowledge, it muſt be confeſſed, is not always ſufficient to comprehend, accurately and diſtinctly, the method which Nature employs in every particular inſtance. Nature, in her great operations, always proceeds in a ſimple way; whereas, we being but humble imitators of that great miſtreſs of chemiſtry, cannot help reſorting to artificial, and thence imperfect proceſſes, whenever we attempt to obtain the ſame products from the ſame principles.

Firſt, as to the origin of the *carbonic acid* in the water of Carlsbad, the opinion of the author of the *Neue Bemerkungen über das Carlsbad*, who deduces the gas of that ſpring from the ſulphur-pyrites themſelves, cannot ſubſiſt;

for, what is extricated from mouldering pyrites is not the carbonic, but the *ſulphureous acid*, combined, according to circumſtances, with *hydrogen gas*. On the contrary, it admits of no doubt, but that *limeſtone* is the principle, which in all caſes, and hence in this alſo, affords the carbonic acid. From the fact already related, that the rock ſeated upon the laboratory of this ſpring is of a younger date, and later formation; it is certain that limeſtone may be preſent at ſome depth; whether it conſiſt of primitive calcareous rock, or of ſtratified calcareous ſtones; and that it actually and neceſſarily there exiſts, is manifeſt from this very daily generation of ſo great a quantity of carbonic acid. But, whether the developement of this elaſtic acid from the limeſtone is effected merely by the heat, or by means of the ſulphuric acid, diſengaged from the diſſolved pyrites, is a queſtion which cannot be *poſitively* anſwered. It is, however, probable, that it is expelled by heat alone.

With regard to the generation of the *neutral ſulphat*, or the *glauber-ſalt*, it undoubtedly cannot take place, but when veins of common ſalt come into contract with diſſolved ſulphur-pyrites. Part of the muriated ſoda is then decompoſed by the ſulphuric acid, and unites with it to a new neutral ſalt, *viz.* the native glauber-ſalt, or ſulphat of ſoda.

And, as the exiſtence of carbonic acid in the Carlsbad water neceſſarily preſuppoſes the preſence of a calcareous ſtratum; the enquiry into the origin of the calcareous earth, diſſolved in this mineral ſpring, is anſwered of itſelf. It is by the ſpontaneous ſeparation of that earth from the water, that the above-mentioned wonderful ſtone-vault, of the great reſervoir, together with the remaining vaſt quantity of variouſly formed ſtalactites and tufas, have been produced, and are daily augmented. Therefore, it is not neceſſary to ſearch in vain, with Dr. *Becher*, and againſt all rules, for the origin of the calcareous earth in the mixture of the pyrites; nor to lay any ſtreſs on the ſmall quantity, which might be an accidental ingredient in the muriated brine, employed by Nature in the production of the mineral ſprings at Carlsbad.

But we cannot judge with equal certainty of the method followed by Nature, in generating the uncombined ſoda exiſting in the Carlsbad water; ſince, of all the methods, which we are able to employ for the ſame purpoſe, there is none of ſuch a kind that we could fairly ſuppoſe to be applied in the operations of Nature, who always accompliſhes her ends by the ſhorteſt ways. It is probable that a long continued influence of the ſubterraneous heat, and humid vapours, are alone ſufficient to volatilize part of the muriatic acid of the muriated ſoda, leaving behind the alkaline principle that had been united with it.

On this predominant portion of free ſoda alſo depends in part the peculiar taſte of Carlsbad water, which, when drank warm, may be compared to a weak meat-broth.

Sulphur-pyrites, *mineral coal*, *limeſtone*, and *brine-ſprings of muriated ſoda*, are, therefore, the raw materials made uſe of by Nature in elaborating thoſe hot mineral ſprings. How enormous the ſtore of them muſt be, may be conceived by reflecting upon the quantity of water, and its ingredients, which is afforded by the *main-ſpring* alone, in the courſe of one year. By the computations of *Dr. Becher*, there iſſue 705 *eimers* in an hour, from the five orifices of that ſpring; which makes, for one day, 16,920; and hence, for the year, 6,175,800 *eimers*. And, if the *eimer* be taken to be equal to *one half cubic foot*, that quantity amounts to 3,087,900 cubic feet of water. Theſe contain:

	Pounds avardupoiſe.
Cryſtallizable ſoda	746,884
———— *ſulphat of ſoda* . . .	1,132,923
Muriat of ſoda	238,209
Calcareous earth	86,020
Siliceous earth	17,369
Oxyd of iron	1,240

Carbonic acid gas 992,539 cubic feet.

And, ſince the quantity of water yielded by the *new-ſpring*, by that *at the mill*, and by the *other ſtreamlets* iſſuing from the clefts of the rifty rock, taken together, may be eſtimated as equal to that afforded ſolely by the main-ſpring; our aſtoniſhment is juſtly excited, on conſidering the immenſe quantity of products which have been ſent forth by thoſe ſprings at Carlsbad, within a term of 420 years; that is, from 1370, which is the period aſſumed in hiſtory for their diſcovery, to 1790.

Yet, no other uſe is made of the great quantity of ſaline contents with which Nature has enriched the Carlsbad-mineral ſprings; except, that yearly, ſeveral hundred pounds of ſulphated ſoda are obtained in the cryſtallized ſtate, by evaporation, and ſold by the name of *Carlsbad-ſalt.* But it would be an object deſerving the exertions of induſtry, if, at the ſame time, pains were taken to recover and employ one part of mineral alkali, or ſoda; inſtead of ſuffering ſo many thouſand pounds of that natural product, ſo valuable with reſpect to our preſent wants, to be unemployed, and carried away into the river *Töpel.*

Before I conclude, I ſhall ſay a few words on a cold *acidulous ſpring*, which is met with behind the brew-houſe, in a granitic rock. This ſpring collects in a ſmall ſhallow baſon, ſituated on the declivity of the rock, and is richly impregnated with carbonic acid, that penetrates through the bottom of the baſon, and covers the fluid in a ſtratum from four to ſix inches thick. Its taſte is ſo exceedingly ſour, that a doubt has ariſen, whether that acidity depends merely on the proportion of the carbonic acid. But experiments have ſhewn it to contain no other extraneous acid; and the quantity of carbonic acid gas was found to be equal in volume to that of the water itſelf, where 18 cubic inches of water have yielded 18 cubic inches of the gas. This *acidulous ſpring* hardly contains any fixed conſtituent ingredients: for, when a conſiderable quantity of it has been evaporated by the aſſiſtance of heat, a reſidue was indeed left, which proved to be a neutral muriat, but ſo ſmall, as almoſt to eſcape obſervation.

This valuable, but, at Carlsbad, little eſteemed ſpring, methinks, deſerves to be protected againſt the caſual impurities by which it is now liable to be defiled, by a more ſuitable incloſure and careful covering; as well as to be more commonly applied, both for *medicinal* and *economical* purpoſes.

XXVI.

CHEMICAL EXAMINATION

OF THE

SALT-SPRINGS AT KÖNIGSBORN,

And their Products *.

THE ſaline ſprings, among others, chiefly belong to thoſe objects, with the inveſtigation of which the induſtry of chemiſts has been hitherto but little occupied. This want of a more ſolid and complete knowledge of the conſtituent parts of the ſaline ſprings cannot fail to have occaſioned a number of erroneous proceſſes in the ſalt-works; and, the neceſſity of aboliſhing or correcting them, is in general ſuggeſted only by the loſs experienced for many years. How many errors would have been avoided in the calculations and eſtimates, if, for inſtance, inſtead of employing the *hydrometer*, that deceitful, empirical ſcale, which hitherto has been almoſt alone reſorted to, and truſted, in aſcertaining the proportion of ſalt contained in any brine, the ſalt-makers had been able to proceed upon the ground of a more certain knowledge, founded on chemical analyſis, of the true ſaline portion, as well as of the other foreign ſubſtances, which are the habitual concomitants of common ſalt? For this reaſon, I believe, that by publiſhing the preſent inquiry into the ſaline ſprings, and their various products, of the *ſalt-works* at *Königsborn*, near *Unna*, in *Weſtphalia*, I am contributing, perhaps, not an unimportant ſhare to a general chemical knowledge of ſaline ſprings.

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* *Sammlung der Deutſchen Abhandlungen der Königlichen Academie der Wiſſenſchaften.* Berlin, 1794.

The ſaliniferous mountain at *Königsborn* conſiſts of a compact, marly limeſtone, ſeparated in ſtrata, and diſintegrable in the air, which ſeem to reſt immediately upon the ſand-ſtone, or red *dead* rock *. They extend in a direction from eaſt to weſt, from *Paderborn*, between the river *Lippe* and *Emſche*, as far as the dukedom of *Cleves*; and they decline, from ſouthweſt to northweſt, into the biſhopric of *Münſter*, where they are covered by ſtrata of ſand and loam. The ſalt-ſprings at *Salzlotten*, *Weſtrinkotte*, *Werle*, *Saſſendorf*, and *Unna*, which have been uſed for many centuries paſt, and ſeveral indications of a weak brine, near *Bochum*, in the *Dortmundt* territory, &c. are likewiſe ſituated on the ſame mountains.

The preſent ſalt-work at *Königsborn* lies about one mile (Engliſh) diſtant from *Unna*, to the north, in a plain; accompanied on both ſides by gentle elevations. Wherever the ground is perforated or dug, at and below Königsborn, towards the north, there are always ſalt-ſprings found; but above Königsborn, ſouthwards, ſprings of ſweet water exiſt, which come forth to the day, and even will riſe in pipes to 10 or 12 feet. On this account, the brine has been procured, for many years paſt, by means of ſuch perforations, of which there have been more than twenty, of a depth from 75 to 280 feet. The brine obtained from theſe, at a depth from 50 to 80 feet, always contains from 1¼ to two ounces of ſalt in the pound; that from 80 to 120 feet, contains 2¼ ounces; but that from 120 to 200 feet, affords 3¼, and even 3½ ounces; and it is pumped up to the height of 12 feet above the ſurface, by means of the above-mentioned wooden pipes, in a quantity amounting to from three to four cubic feet every minute. Experience has ſhewn, that this ſaline ſpring has decreaſed in dry weather, in quantity of water, and richneſs of ſalt; but has increaſed, in both reſpects, in wet weather, or when in the midſt of ſummer it has rained only a few days, after a great drought. However, after the lapſe of four or ſix years, the brine has been ſo much impoveriſhed, at every well, as to yield only 1½ ounce of ſalt; although neither the quantity flowing out had increaſed, nor had the brine been otherwiſe altered. As often, therefore, as this happened, a new perforation has been made, by which means a brine, 3 or 3¼ ounces, rich in ſalt, was again obtained for ſome time. From this account it would ſeem, that there exiſt three diſtinct ſalt-ſprings lying upon each other; that the deepeſt are the richeſt; which, therefore, by their riſing, force away the upper and lighter ones; and, that theſe laſt muſt be in conjunction with ſome ſtream, the ſweet water of which waſhes a maſs of ſalt, and thereby becomes impregnated with part of it. Hence may be explained the rapid increaſe of the quantity of the fluid, and of its proportion of ſalt, after rainy weather. In conſequence of this conjecture, ſome years ago, ſhafts were ſunk between the ſeveral borings; the lighter ſprings were ſtopped up, and the richeſt were brought out to the day. However, the event was, that by means of this perforation, at the 111th foot in depth, a copious ſpring was come at, but only one ounce in richneſs; which poured into the well, that was already 60 feet

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* By the *dead rock* is underſtood the ſtone, or ſubſtance, which lies between the primary and ſecondary ſtrata, and participates of the nature of both. The Germans call it *todt-liegendes*; *Kirwan* calls it *ſemiprotolite*, and likewiſe *deadlier*. See his *Geological Eſſays*. Lond. 1799. page 225; and his *Elements of Mineralogy*. Lond. 1794. vol. i. page 363.—Tranſl.

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deep, in ſuch quantities, that at every minute 25 cubic feet were to be overcome. On the very day that this ſpring had been pierced, the ſaline contents in the ſeveral brines augmented in all the wells, from 1¼ ounce to 1½, 2, and even 2¼ ounces. This weak brine, therefore, ſeems to impoveriſh the richer ones, by penetrating through the fiſſures of the marly rock to the perforated cavities; and either keeping off the deeper ſprings of 3 ounces richneſs in ſalt, or mixing with, and thus lowering them down to 1 and 1¼ ounce.

To ſhew what quantity of ſalt may be procured from theſe ſprings, I ſhall ſelect the period of three years; namely, from the 1ſt of June, 1788, to the laſt of May, 1791. During that time were procured:

35,521,534 pounds.

This gives for one year:

11,850,511⅓ pounds.

By taking into the calculation the loſs occaſioned by the *boiling*, which has been aſcertained by actual experiment, as well as the loſs ariſing from the *graduation* *; which, by eſtimation, is reckoned at 37 *per cent*, there will be required of the brine, to obtain the above produce in each year:

336,069,731 pounds; or,
4,972,748⅓ cubic feet.

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* In other words: from evaporating the brine by means of air, previous to their boilings, in particular buildings, called *graduating-houſes.* Conſult *Gren's Principles of Modern Chemiſtry.* Lond. 1800. vol. i. page 294.—Tranſl.

In ſpeaking of the chemical examination of thoſe ſprings, to avoid unneceſſary repetitions, I ſhall only in general explain the method in which I have proceeded in this inquiry; and, with reſpect to each particular ſpring, &c. I ſhall merely ſtate the reſult of my experiments:

1.) In order to determine the ſpecific gravity of each brine, I meaſured 50 cubic inches (each equal to 290 grains of diſtilled water); weighed, and compared them with the weight of an equal quantity of diſtilled water.

2.) Theſe 50 cubic inches of brine were then evaporated, in a ſand-heat, to a dry reſidue, and the weight of it noted.

3.) Theſe reſidues were then covered in cylindrical glaſs-veſſels, with alkohol, and extracted by means of it during 24 hours, at a moderate temperature, and with repeated ſtirring.

4.) After the alkohol had been again ſeparated by filtration, it was evaporated to dryneſs. Upon the reſidue left by it, freſh ardent ſpirit was affuſed, in ſuch a quantity as was neceſſary to ſeparate the ſmall portion of common ſalt, which had united with the ſpirituous ſolution, at the firſt extraction. After this, the laſt alkohol was likewiſe evaporated, and the reſidue weighed.

5.) That portion which had been extracted by alkohol conſiſted of *muriat of lime*, mixed with a very trifling portion of *muriated magneſia*; the proportion of which laſt was determined in the following manner:—The reſidue, obtained by the evaporation of the alkohol, was diſſolved in water, the ſolution heated, and the earth precipitated by ſoda. This earth, when waſhed, was combined with ſulphuric acid, added in exceſs. After the mixture had ſtood for a while in a warm place, and the predominant acid had been again abſorbed by carbonat of lime, which was added for this purpoſe, the liquor was freed from the ſelenite or gypſum then generated, and evaporated by a gentle heat. When the ſelenite, which ſtill appeared, was again ſeparated, and the liquor ſufficiently reduced, the ſolution was expoſed to ſpontaneous exhalation in the open air, and thus made to cryſtallize. The ſulphat of magneſia, produced by this proceſs, was rediſſolved in water, and decompoſed by ſoda; upon which the magneſia, which ſeparated, was ſaturated with muriatic acid, evaporated to dryneſs; and the weight of this muriated magneſia ſubtracted from the muriated lime.

6.) The deſiccated muriat of ſoda, remaining after the ſeparation of thoſe deliqueſcent ſalts, by means of alkohol, was next diſſolved in water, and filtered.

7.) The remainder on the filter conſiſted of *ſulphat* and *carbonat of lime*; and in ſome, brines of *oxyd of iron.*— When weighed, it was treated with muriatic acid, and the ſelenite ſeparated upon the filter. The filtered ſolution, when it appeared to contain a ſeparable portion of iron, was combined with cauſtic ammoniac; and the oxyd of iron, which fell down as a brown flocculent precipitate, when collected by the filter and ignited, was weighed, and its weight reduced to that of carbonated iron.

8.) I combined the muriatic ſolution of No. 6 with carbonat of ſoda, aſſiſted by heat, when a precipitate enſued, conſiſting of carbonated lime. The ſoda, employed for its precipitation, having thus been again neutralized by the muriatic acid, I treated this muriatic ſolution with muriated barytes. From the ſulphat of barytes, obtained by this management, it was obvious that the calcareous earth precipitated, by the carbonated ſoda, from the diſſolved muriat of ſoda, had been combined with ſulphuric acid in the character of *ſelenite.* In like manner, it followed from the proportion, which the quantity of ſulphuric acid bore to the calcareous earth, obtained in a ſtate of combination with it, that the muriatic ſolution contained ſelenite only, and no glauber-ſalt, nor any other alkaline or earthy ſulphat. The total abſence of theſe laſt was alſo confirmed by this; that the dry ſalt gradually diſſolved in a mixture of two parts of alkohol with one of water, which I affuſed upon it; and, that at laſt nothing but ſelenite remained.

The experiments, performed in the manner here explained, gave the following reſults:

A.

Brine of the Varsthauſer-ſpring.

Its ſpecific gravity was 1039 (diſtilled water being 1000).

Fifty cubic inches, evaporated to dryneſs, afforded a grey-white reſidue, weighing 882 grains.

This reſidue conſiſted of:

Muriat of lime	46 grains.
——— *magneſia* . . .	1
Carbonat of lime	12
Selenite, or ſulphat of lime .	25
Muriat of ſoda . . .	798
	882

B.

B.

Brine of the Glückauf-ſpring.

Its ſpecific gravity was found to be 1029.

Fifty cubic inches left a pale-red reſidue of 585 grains, containing:

Muriat of lime	32 grains.
——— *of magneſia* . . .	1
Carbonat of lime	11
Carbonated oxyd of iron .	1
Selenite	18
Muriat of ſoda, or *common ſalt*	522
	585

C.

Brine of the Frederic-anton-ſpring.

Its ſpecific gravity was 1025.

Fifty cubic inches left, by evaporation, 540 grains, of a light-reddiſh reſidue, conſiſting of:

Muriated lime, including a ſcarcely obſervable trace of *muriated magneſia*	20 grains.
Carbonated lime, or crude calcareous earth	11½
——— *oxyd of iron*	½
Selenite, or gypſum	14
Muriated ſoda	494
	540

D.

Brine of the Goldener Sonnen-ſpring.

The ſpecific gravity was 1024.

The dry reſidue, yielded by 50 cubic inches, had a light-grey-white colour, and weighed 521 grains. It was reſolved into:

Muriat of lime	30	grains.
——— *of magneſia* . . .	½	
Carbonat of lime	11	
Selenite	15	
Muriat of ſoda . . .	464½	
	521	

E.

Brine of the Ludwigs-ſprings.

Its ſpecific gravity 1023.

The light-reddiſh reſidue, from 50 cubic inches of the evaporated brine, weighed 508 grains, and contained:

Muriat of lime	20	grains.
Carbonated lime	10	
——— *oxyd of iron* . .	½	
Selenite	13	
Common ſalt, or muriated ſoda	464½	
	508	

The brine, which is brought up from the various ſalt-ſprings, is conducted into one common reſervoir, from which it is pumped to the top of the *graduating-houſes*, where it is three times *graduated.*

F.

Brine of the firſt graduation.

Its ſpecific gravity roſe to 1060. The reſidue from the evaporation of 50 cubic inches weighed 1285 grains; and conſiſted of:

Muriated lime	65	grains.
——— *magneſia*	1½	
Carbonated lime, containing ſome iron	4½	
Sulphated lime, or ſelenite . . .	44	
Muriated ſoda	1170	
	1285	

G.

Brine of the ſecond graduation.

Specific gravity 1076.

Fifty cubic inches, evaporated, gave a reſidue of 1615 grains. This was decompoſed into:

Muriat of lime	75	grains.
——— *of magneſia*	2	
Carbonat of lime	3	
Selenite	48	
Muriat of ſoda	1487	
	1615	

H.

Brine of the third graduation.

Its ſpecific gravity amounted to 1086.

Fifty cubic inches of it have left, upon evaporation, 1850 grains of a dry reſidue, containing :

Muriat of lime	82	grains.
——— *of magneſia*	3	
Carbonat of lime	3	
Sulphat of lime (ſelenite)	52	
Muriat of ſoda (common ſalt) . .	1710	
	1850	

The ſalt obtained by boiling from theſe *graduated* brines is of two ſorts, of which the one is deſtined for *foreign*, and the other for *home* conſumption. The *firſt* conſiſts, for the moſt part, of conſiderably large, four-ſided, hollow cryſtals, compoſed, in a funnel-like manner, of ſimple cubes of muriated ſoda. Such cryſtals are always formed on the ſurface of the brine, when they can evaporate without agitation. The *ſecond* ſort is externally diſtinguiſhed from the preceding by ſomewhat ſmaller and leſs regular cryſtals.

I.

Common ſalt for exportation.

One pound of it, that had been completely deſiccated with the aſſiſtance of heat, was pulverized, and then examined by the method above-deſcribed. It conſiſted of:

	Oz.	drach.	gr.
Moiſture, expelled by the drying .	—	3	—
Accidental impurities, and ſand . .	—	—	10
Muriated lime	—	—	25
Selenite	—	1	30
Pure muriat of ſoda	15	2	55
	16 Ounces.		

K.

Common ſalt for home-conſumption.

One pound of it, treated as the laſt, contained:

	Oz.	drach.	gr.
Moiſture	—	4	30
Accidental impurities . . .	—	—	18
Muriated lime	—	—	30
Selenite	—	1	35
Pure muriat of ſoda . . .	15	—	7
	16 Ounces.		

L.

Mother-water.

The mother-brine proved to be of conſiderable ſpecific gravity; namely, 1218.

Fifty cubic inches of it, when evaporated, yielded 5440 grains of dry ſalt, which I divided into two parts, ſubjecting each to a ſeparate examination.

1) 2720 grains, or one half of the ſalt obtained from the mother-water, and decompoſed after the manner ſo often mentioned, gave:

Muriated calcareous earth . . .	330 grains.
——— *magneſian earth* . . .	420
Sulphated calcareous earth . . .	50
Common ſalt	1920
	2720

2) The other half of the ſalt, afforded by 50 cubic inches of the mother-water, I re-diſſolved in water, and evaporated the ſolution to the point of cryſtallization. I obtained from it, at five ſucceſſive ſhootings, 4 ounces and 2 drachms of cryſtallized muriated ſoda, but which was ſtill contaminated by the mother-water which adhered. For this reaſon, I diſſolved it once more in water, and cryſtallized it anew; by which treatment I then obtained 3 oz. 7 dr. of pure common ſalt. By this it was rendered evident, that every cubic foot of that mother-water, if treated in the ſimple way of cryſtallization, would ſtill afford 16 or 17 pounds of pure muriat of ſoda. The mother-water of both cryſtallizations was diluted with water, and its earthy portion, precipitated by ſoda, weighed 544 grains, when waſhed and ignited. This precipitate conſiſted of *calcareous* and *magneſian* earth; which I ſeparated, by ſaturating the maſs with ſulphuric acid. When the ſulphat of magneſia had been filtered off from the ſulphat of lime which was formed at the ſame time, I decompoſed it by means of ſoda. The magneſia, then obtained in a pure ſtate, and weighing 290 grains, by treating it with muriatic acid, was converted into muriat of magneſia, which, evaporated to dryneſs, amounted to 420 grains; exactly as it did in the foregoing proceſs.

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This portion of muriated magneſia, contained in the mother-water along with the muriated lime, and exceeding the latter in quantity, deſerves particular notice. In both brines, in the *graduated* as well as the rough, the muriated magneſia amounted only to the 30th or 40th part of the muriated lime; in the mother-water, on the contrary, the quantity of the firſt exceeds the latter nearly by one fourth part. The cauſe of this ſeems to lie in the following circumſtance:—It is cuſtomary, at Königsborn, to preſerve the mother-water of 4, 5, or more boilings in the boiler. At any ſubſequent boiling, therefore, a ſtronger heat is required, to promote the cryſtallization of the ſalt; and when, in this caſe, a part of the bottom of the boiler becomes dry, a portion of the muriated lime is then decompoſed, and its earthy baſis becoming *free*, increaſes the calcareous earth in the *ſchlot*, or incruſtation (*pfannenſtein*) of the veſſel: but the muriatic acid eſcapes in vapours, as may diſtinctly be perceived by the ſmell.

M.

Incruſtation of the boiler.

One Pound of it, pulverized and dried in a gentle heat, was boiled with 12 lb. of water. The filtered ſolution was next evaporated to dryneſs, and the ſalt obtained was treated in the method all along mentioned. When the undiſſolved, grey-white, earthy reſidue was examined, it proved to be a mingled maſs of ſulphat of lime, of *carbonated lime containing a little iron*, and of a ſandy *ſiliceous earth*.

The proportion of theſe conſtituent parts to each other was found to be as follows:

	Oz.	*drach.*	*gr.*
Moiſture	1	6	—
Muriated lime	—	1	10
——— *magneſia*	—	—	10
Muriat of ſoda, with a ſcarcely perceivable *trace of ſulphated ſoda*,	4	4	40
Carbonat of lime	1	2	30
Sandy ſiliceous earth	—	3	30
Sulphat of lime (ſelenite) . . .	7	6	0
	16 Ounces.		

N.

Dornenſtein.

(That is, the earthy and ſaline incruſtations formed on the bruſh-wood in the *graduating* houſes.—Tranſl.)

The *Dornenſtein* of theſe ſalt-works conſiſts of a dark-brown, compact, indurated, ſtony cruſt, ſimilar to the incruſtations at *Carlsbad.*

1.) Of this I boiled *two ounces*, reduced to powder, with a ſufficient quantity of water. This, however, would diſſolve but little; for, after evaporation, there remained only four grains of common ſalt, mixed with iron and ſelenite.

2.) The powder of the ſtone which remained after boiling was ſaturated with muriatic acid. The ſolution was attended with great effervefcence, and, towards the end, was promoted by heat. When filtered, it left ſelenite behind.

3.) This muriatic ſolution, combined with cauſtic ammoniac, depoſited a quantity of iron in a flocculent form; the weight of which, firſt aſcertained when collected and ignited, was afterwards reduced to that of carbonated iron.

4.) The ſolution, now perfectly colourleſs, afforded carbonat of lime, by the addition of ſoda.

The proportion of the ingredients in theſe two ounces, or 960 grains of the mentioned *Dornenſtein*, was :

Impure common ſalt . . .	4	grains
Selenite	25	
Carbonated oxyd of iron . .	92	
——— *calcareous earth* .	828	
Moiſture	11	
	960	

What corrections, or improvements, might be made in the boiling of ſalt in the *ſalt-works* at *Königsborn*, in conſequence of the analyſis here communicated of the ſalt-brines, or ſprings of that place, and their products, I leave to the judgment of practical *halurgiſts*, or ſalt-makers.

But the advantage which the ſcience may derive from the performance and collection of theſe and ſimilar analyſes, cannot be doubted : thereby, not only the ſum of our obſervations hitherto collected, on the nature and conſtituent parts of ſalt-ſprings in general, will be rendered more complete and certain; but likewiſe the knowledge of the laws of elective attractions of bodies, in particular, will be in-

increaſed and corrected. An inſtance of this laſt is afforded in the preſent analyſis, by the circumſtance that, in theſe ſalt-brines, no glauber-ſalt is found, but only ſelenite; although the latter, ſituated in the proportion in which it is contained in the mixture, ſhould be decompoſed according to the laws of affinities: at the ſame time that the ſoda of the common ſalt ſhould combine with the ſulphuric acid of the ſelenite, to form glauber-ſalt. But it muſt be here conſidered, that the agency of the attractive forces in bodies likewiſe depends on the various degrees of temperature: and this is really the caſe in this inſtance: for it is ſhewn, by experience, that the generation of ſulphat of ſoda from the muriats of lime and ſoda, or, in other words, the generation of glauber-ſalt from ſelenite and common ſalt, can take place only at a cold, much below the point of freezing; but to ſuch a low temperature the ſalt-ſprings are not expoſed in their ſubterraneous reſervoirs and canals. Whence it alſo happened, that when, with this view, I repeated the experiment with 16 ounces of the maſs which incruſted the boiler *(pfannenſtein)*, and which, during the winter, had been expoſed to the cold, and had, in part, fallen to pieces, the newly-generated glauber-ſalt immediately appeared. Its quantity, aſcertained by means of muriated barytes, and calculated for the cryſtalline ſtate, did, however, in general, amounted to no more than 36 grains.

Finally, the *carbonic acid* muſt alſo be added to the conſtituent ingredients in ſaline ſprings. This acid is extricated, in the uſual form of air-bubbles, during the evaporation of the *rough* brine; and its diſengagement cauſes the ſeparation of the calcareous earth, now deprived of its ſolvent. The ſame eſcape of this volatile acid, and the ſame ſeparation of the calcareous earth, likewiſe take place when the brines are *graduated*; in which caſe the carbonated calcareous earth, together with the oxyd of iron, ſettles around the bruſh-wood, through which the brine paſſes, and forms the *dornenſtein*. On this account, the *graduated* brines contain a much ſmaller proportion of calcareous earth; which, at the proceſs of boiling, is fully depoſited, and aſſiſts, in combination with the ſelenite, to form the compound with which the boiler is incruſtated. (*Pfannenſtein*).—What concerns the proportion of *carbonic acid*, contained in ſalt-ſprings, in a ſtate of abſorption, I did not, in particular, attempt to aſcertain; as ſuch enquiries cannot be made with any proſpect of ſucceſs, but with brines recently collected, and employed on the ſpot.

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XXVII.

CHEMICAL EXAMINATION OF *SPINELL.*

THE *ſpinell* ſeems to belong to thoſe ſpecies of gems, which the antients underſtood by the name *Hyacinth*; as they do not aſcribe to it the yellowiſh red colour, poſſeſſed by our modern hyacinth, but a light violet-red, and alſo a roſe-red. Pliny [*], for example, ſays:—"*Multum ab amethyſto diſtat hyacinthus, tamen e vicino deſcendens. Differentia hæc, quod ille emicans in amethyſto fulgor violaceus, dilutus eſt in Hyacintho.*" *Epiphanius* enumerates five ſpecies of hyacinth, the *third* of which he calls NATIBOS [†], ſtated by *Salmaſius* to have been of a colour, *qui inter roſeum eſt, et dilutiorem.* That the ſtone, now called hyacinth, has been miſtaken for the hyacinth of the antients, was probably occaſioned by the following paſſage of *Pliny* [‡]:—"*Hyacinthos Æthiopia mittit et chryſolythos aureo colore tranſlucentes.*" But if in conſequence of a ſounder criticiſm the context be read thus:—*Marceſcens celerius nominis ſui flore hyacinthus. Æthiopia mittit et chryſolithos*, &c. it is obvious, that the *aureus colour* is referred to the chryſolite, which, as is well known, is the *topaz* of our days, and that it has nothing to do with the *hyacinthus* of the preceding ſentence. In this way, alſo, another apparent contradiction in Pliny is removed.

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[*] Lib. xxxvii. cap. 9.

[†] From the Arabic word, *Natif*, a red crayon colour. *See Joan. de Laet de Gemmis et Lapidibus.* Lugd. Batav. 1647.

[‡] Loc. cit.

The reader likewiſe knows that the ſpinell has been hitherto ranked along with the *ruby* as its ſecond ſpecies, ſo that the firſt ſpecies of that genus has included the true genuine ruby. But ſince *Rome de l'Iſle*[*] has directed the attention to the different form of cryſtallization of thoſe two ſtones: obſerving that the cryſtals of the genuine ruby of *Pegu* are oblong, double, hexahedral pyramids, modern mineralogiſts have, upon this ground, ranked the *ruby* under the ſapphire, as a red variety of it, and introduced the *ſpinell* as a diſtinct genus; which ſeparation is alſo ſuggeſted by the difference of its hardneſs and ſpecific gravity.

Beſides theſe diſtinctions, the nature of the fracture alſo might ſerve to diſcriminate the genus. For the texture of the ſpinell is lamellar, in triple tranſverſe laminas; the ſapphire, on the contrary, exhibits in every direction only a flat conchoidal fracture[†].

Yet the ſureſt way to decide on this point would be by chemical analyſis; which, however, with reſpect to the ruby cryſtallized in hexhedral pyramids, or the red ſapphire, can be at preſent but little hoped for, as it is ſo ſeldom met with in its rough ſtate.

The original figure of ſpinell is the octahedron, or double four-ſided pyramid. This cryſtalline figure is frequently found perfectly regular, but as often ſubject to many variations, which have been detailed and deſcribed with great diligence, and uncommon accuracy, by Abbé *Estner*[‡].

No leſs variable is the colour of the ſpinell; as it paſſes through almoſt all the ſhades of the red. This variation of colour has induced jewellers, or dealers in gems, to ſubdivide the genus of ruby, beſides the *genuine ruby*, into *almandin*, *ſpinell*, *ballaſs*, *and rubicell*, as they uſually do.

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[*] *Criſtallographie*, tom. i. page 213.

[†] *Estner, Mineralogie*, II. B. I. Abth. S. 96, 97.

[‡] *Ibidem*, page 73. ſeq.

The red colour of this gem is not only very fixed, or permanent in the fire, but its pale variations are even ſtill more heightened by means of a careful ignition. This property the inhabitants of Ceylon know how to employ to advantage, according to the teſtimony of *Julius Scaliger*;* and, perhaps, on this dexterity of art depends the amazingly high and magnificent colour which we admire in fine, poliſhed rubies, but do not perceive in the rough, uncut ſtones.

To the more uncommon variations of colour belong: 1. the ſpinell, quite *colourleſs*, and as limpid as water, of which Mr. *Macie*, in London, poſſeſſes a perfect octahedron in his collection of cryſtals; 2. the *ſapphire-blue* ſpinell, in the collection of *Francis Greville*, Eſq.; and 3. the *green* ſpinell, the property of *J. Hawkins*, Eſq. likewiſe in London, &c. &c. This affords a new example, that, in determining the genera and ſpecies of gems, colour is to be conſidered as only a ſubordinate or *ſecondary* character.

The ſpecific gravity of ſpinell I have found to be, in ſelected cryſtals, from 3,570 to 3,590.

Although ſeveral years ago I attempted and publiſhed a chemical analyſis of the ſpinell†, I have found ſome circumſtances then not completely aſcertained, which require another analytical proceſs. The reſult of this has taught me, that on the firſt analyſis of the ſpinell, I had thoroughly overlooked one of its conſtituent parts, which I did not ſuſpect in it, and which is *magneſian-earth*. Among the various experiments, inſtituted for accurately determining the proportion of this newly diſcovered ingredient, I ſelect that in particular, which led the neareſt to fulfilling this object.

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* *Exercitationes*, &c. No. cxviii.

† *Beob. u. Entdeck. a. d. Naturkunde*, vol. iii. Berlin, 1789. page 336.

a) *One hundred* grains of rough ſpinell from Ceylon, in picked cryſtals, previouſly pounded to a coarſe powder in the ſteel-mortar, were triturated with water to an impalpable powder in the grinding-diſh made of flint. After the powder of the ſtone, which was again dried, had been gently ignited, it ſhewed an increaſe of weight of nine grains, originating from the particles abraded from the ſubſtance of the grinding-veſſel.

b) I then ſtrongly digeſted that powder with two ounces of muriatic acid. When the acid had been evaporated nearly to dryneſs, I diluted the maſs with water, threw it upon the filter, and ſaturated the yellow muriatic ſolution with cauſtic ammoniac. A brown flocculent *oxyd of iron* fell down, which, collected and ignited, weighed 1¼ grain.

c) The liquor ſeparated from that precipitate was concentrated by evaporation, perfectly neutralized with muriatic acid, and, laſtly, combined with diſſolved oxalat of pot-aſh (ſalt of wood-ſorrel). In conſequence of this, oxalat of lime precipitated; which, when carefully collected, and heated to redneſs in the cavity of a compact piece of charcoal, with the aſſiſtance of the blow-pipe, afforded three fourths of a grain of lime, or pure *calcareous earth*. This laſt, diſſolved in nitric acid, and treated with the ſulphuric, produced ſelenite, or ſulphated lime.

d) Upon the powder of the ſtone, extracted by the muriatic acid, was poured ten times its quantity of alkaline lye, one half of which conſiſted of cauſtic alkali; which mixture being firſt evaporated to dryneſs, in a ſilver-veſſel, upon a ſand-heat, was afterwards ignited during the ſpace of an hour. When the maſs had been again ſoftened with hot water, it left on the filtering paper 54 grains of an iſabella-yellow reſidue when dried in the air.

e) Theſe 54 grains were a ſecond time mixed, and inſpiſſated with a tenfold quantity of the ſame cauſtic lixivium, and afterwards ignited. Upon which, the maſs, ſoftened again with water, depoſited a reſidue of a fine pulverulent form, weighing 43 grains, when dried in the air.

f) I then neutralized the yellow alkaline ſolution (*d*) and (*e*) by means of ſulphuric acid, and by affuſing more acid, made a clear ſolution of the precipitate, which then formed. Carbonat of pot-aſh, added in a boiling ſtate, threw down from it a precipitate of a very great bulk, which, after edulcoration, was again diſſolved in ſulphuric acid. This ſolution exhibited a ſlimy toughneſs; but it became perfectly fluid, when expoſed to a raiſed temperature, and depoſited a ſubtle white powder, which, after waſhing and deſiccation in the air, weighed 95 grains. The ſulphuric acid fluid, when ſeparated from it, was ſet aſide for a time.

g) The above-mentioned 95 grains were then gently ignited with thrice their quantity of cauſtic pot-aſh. When again liquefied with water, and filtered, there remained only a ſlight reſidue, which, after waſhing, diſſolved in ſulphuric acid, with the exception of a few remaining particles.

h) The portion taken up by the cauſtic pot-aſh in the alkaline ſolution (*g*), was precipitated by means of ſulphuric acid. But it diſſolved again in the acid, when added to exceſs, and was afterwards precipitated by boiling with mild, or carbonated alkali. This precipitate, previouſly waſhed, was once more diſſolved in ſulphuric acid.

i) The whole of the ſulphuric ſolutions, obtained at (*f*, *g*, *h*), was evaporated to a ſmaller compaſs. The gelatinus conſiſtence, into which it congealed, ſhewed that a ſeparation of ſiliceous earth had taken place. It was therefore largely diluted with water, digeſted, and the ſilex collected upon the filter.

k) This done, the ſulphuric ſolution was put in a ſtate to cryſtallize, by dropping into it a ſolution of acetite of pot-aſh*, and evaporating it ſlowly. It yielded at firſt regular and pure cryſtals of alum. But as the ſolution aſſumed a green colour towards the end, I combined it with Pruſſian alkali. A trifling precipitation enſued, of which the *oxyd of iron* could not be eſtimated more than at one fourth of a grain. The ſolution, being now freed of its ferruginous ingredient, was next decompoſed, in a boiling heat, by carbonated pot-aſh; and the precipitate, when diſſolved anew in ſulphuric acid, was brought to a final cryſtallization; after which the ſulphat of alumine then obtained was added to the foregoing.

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* *Note.* In order to add the vegetable alkali in the juſt proportion requiſite to promote the cryſtallization of the ſulphated alumine, I find it at preſent moſt convenient to employ that alkali in a ſtate of ſaturation with acetic acid. By this manner I avoid the danger of decompoſing a part of the alum juſt forming, by the quantity of alkali, that may eaſily happen to be added in exceſs.

l) I now proceeded to the analyſis of the 43 grains, that were left undiſſolved by the cauſtic alkaline lye (*e*). Theſe readily diſſolved in dilute ſulphuric acid, leaving ſome ſiliceous earth behind. The ſolution, ſeparated from this laſt, was then combined with a ſmall portion of acetated pot-aſh, and expoſed to ſpontaneous cryſtallization by exhalation in the open air. At firſt there yet appeared ſome ſolitary cryſtals of alum; but afterwards it entirely ſhot into *ſulphat of magneſia* (Epſom ſalt).

m) To ſeparate the ſulphated magneſia, thus obtained, from the admixed ſulphat of alumine, it was ſtrongly ignited in a porcelain-veſſel during half an hour, and the ſaline maſs afterwards ſoftened in water, and filtered. The aluminous, or argillaceous earth, ſeparated by this management, was afterwards diſſolved in ſulphuric acid, and in the proper manner cryſtallized into concrete alum.

n) The pure ſolution of the ſulphated magneſia was precipitated in a boiling heat by means of vegetable alkali. The *magneſian earth*, thus obtained in a carbonated ſtate, weighed 20½ grains, when waſhed and dried; but after ſtrong ignition it weighed only 8¼ grains.

o) All the waſhings (of which that at (*f*), on precipitating the ſulphuric ſolution by carbonat of pot-aſh, retained the yellow colour of the firſt ſolution) were, together, evaporated to a dry ſaline maſs. When they had been re-diſſolved in water, there ſtill ſeparated a little earth, which, along with the precipitate remaining at (*g*), was ignited with cauſtic pot-aſh, and then by ſulphuric acid reſolved into *aluminous* and *ſiliceous* earths.

p) The whole quantity of alum obtained at (*k*, *l*, *m*, and *o*) amounted to 665 grains. It was now diſſolved in water, and in a heat of ebullition decompoſed by carbonated alkali prepared from tartar. The *aluminous earth*, thus obtained, when edulcorated with water, and dried in a moderate warmth, weighed 221 grains. But, after being purified by digeſtion with diſtilled vinegar, and ſubſequent ſaturation with ammoniac, and being again edulcorated, and at laſt ſubjected for half an hour to an intenſe red heat, it weighed no more than 74½ grains.

q) I then ignited, for half an hour, the whole of the *ſiliceous earth* collected from (*i*, *l*, *o*). Its weight was 24½ grains. Hence, ſubtracting the nine grains which had been abraded from the flint-mortar (*a*), there remain 15½ grains belonging to the ſpinell.

From this analyſis it follows, that the conſtituent parts of the *ſpinell* in the *hundred* are:

Alumine	*p*)		74,50
Silex	*q*)		15,50
Magneſia	*n*)		8,25
Oxyd of iron	*b*) 1,25 *k*) 0,25		1,50
Lime	*c*)		0,75
			100,50

The reaſon why, in this inſtance, there appears in the ſum of the weights an exceſs of half a grain, rather than a loſs, unavoidable in the uſual courſe of ſuch proceſſes, is probably, that the ignition was not powerful enough to effect in thoſe ingredients that high degree of dryneſs, which that ſtone poſſeſſes in its natural, undecompoſed ſtate.

With regard to another analytical proceſs made with ſpinell, and of which it would be ſuperfluous to give a detailed deſcription, as it only ſerved to pave the way to the foregoing, I ſhall here merely relate the following phenomenon.—When the coheſion of the parts which conſtitute that ſtone had been looſened by alternate treatment with cauſtic pot-aſh and muriatic acid, I introduced the earth, precipitated by ammoniac from the muriatic ſolution, into cauſtic alkaline lye. It diſſolved therein for the moſt part, but not wholly. The undiſſolved remainder was upon this diſſolved in muriatic acid; and when the ſiliceous earth, which then appeared, had been removed, the fluid was again evaporated to a ſmaller volume.

After ſome days ſtanding, there appeared in it a quantity of ſmall cryſtalline groups, conſiſting of clear, and ſeemingly quadrilateral, ſomewhat flattened, little columns; the greater number of which were joined by two and two, in the form of an X, but the others in groups of three, and more, in a ſtellated manner.

Theſe cryſtals readily diſſolved in water. The precipitate, thrown down by cauſtic ammoniac, was of a light-brown, on account of ſome portion of iron, which ſtill adhered. It was then diſſolved in ſulphuric acid, and this new combination was again ſet to cryſtallize in the ſloweſt manner. At firſt there appeared cryſtals of alum; but the remainder of the ſolution gradually ſhot into four-ſided columnar cryſtals of ſulphated magneſia.

It is this cryſtallization of *magneſia*, mixed with *alumina* in muriatic acid, which I think worth remarking.

XXVIII.

CHEMICAL EXAMINATION

OF THE

EMERALD from Peru.

THE *emerald* is one of the beſt known gems, and it has been reckoned even in remote antiquity among the moſt eſteemed precious ſtones, on account of its rich green colour, ſo grateful to the eye. *Pliny* enumerates *twelve* ſpecies of it, and conſiders the *Scythian*, *Bactrian*, and *Egyptian*, as the moſt eminent. However, it can hardly be doubted, but that, in thoſe days, various eſſentially different ſpecies of ſtones of a green colour were compriſed under that name; as is frequently done in our days. The acquaintance of Mineralogiſts with the genuine emeralds, which were furniſhed by the parts of the globe the longeſt known, ſeems at preſent to be almoſt entirely obliterated by our familiarity with thoſe which are found, though ſparingly, in the provinces of *South-America*, and *principally* in *Peru*.

a) For the following analyſis I made uſe of the crude, cryſtallized emerald, of a high graſs-green colour, from *Peru**. I pounded it in a ſteel-mortar to a coarſe powder, and triturated *one hundred* grains of that powder very finely with water, in the flint grinding-diſh. After gentle ignition, I found its weight increaſed by about 1½ grain.

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* For the ſpecimen of emerald ſacrificed to this analytical proceſs, I am indebted to the liberal kindneſs of Prince *Dimitri Gallitzin*, whoſe zeal for the ſtudy of Mineralogy is moſt honourably known.

b) The powder of the ſtone was covered, and ſeveral times digeſted in a ſtrong heat, with muriatic acid; which immediately acquired a yellow colour. After having again filtered off the acid, I ſaturated it to exceſs with cauſtic ammoniac; and by this management there ſeparated light, brown flocculi, which, collected and ignited, weighed half a grain, and were *oxyd of iron*. The fluid was next evaporated to a part, and treated with carbonated ammoniac. But it continued clear, and thus ſhewed, that it contained no calcareous earth.

c) *Fourteen* drachms of cauſtic alkaline lye, made of ſeven drachms of the ſalt diſſolved in as many of water, were then affuſed upon the powder of the ſtone extracted by the muriatic acid (*b*); and after the maſs had been previouſly evaporated to dryneſs in a ſilver-crucible, I ſubjected it to a red-heat for half an hour. However, it would not fuſe, but appeared, after ignition, in an intumeſced, friable ſtate, and of a white colour.

d) On being ſoftened with water, and treated with abundance of muriatic acid, it afforded a very limpid ſolution, from which the earthy ingredient was precipitated by carbonated pot-aſh, with the aſſiſtance of heat. The precipitate had a granular form; and when finely ground, the greateſt part ſeemed to diſſolve in muriatic acid, which was poured upon it. But as ſoon as the mixture had been expoſed to a digeſting heat, it coagulated to a tranſparent thick jelly. When diluted, and digeſted with more water, it depoſited ſiliceous earth to the amount of 67 grains, after waſhing and ignition. This earth was then mixed with four parts of carbonated pot-aſh, and ignited to an incipient fuſion, in a crucible made of ſilver. Upon the maſs, rediſſolved in water, which afforded a ſomewhat turbid ſolution, I poured muriatic acid to an exceſs of ſaturation, and digeſted them together. The *ſiliceous earth*, which I thus recovered, was now perfectly pure, and weighed 63½ grains, after having ſuſtained a red heat.

e) The muriatic ſolution, ſeparated from this ſilex, together with the preceding (*b*), was ſaturated with an overproportion of cauſtic ammoniac. The paſte-like precipitate, thence ariſing, was immediately removed, and the filtered liquor combined with carbonat of ammoniac; which, however, would throw down nothing more. Sulphuric acid quickly diſſolved this precipitate. By the addition of a little acetite of pot-aſh, the whole of the ſolution yielded cryſtallized alum, with the exception of ſome *ſilex*, which ſtill ſeparated, and weighed 4½ grains, after ignition.

f) From the above ſulphat of alumine (*e*) being re-diſſolved in water, I precipitated the argil by carbonated potaſh. When the earth had been again deſiccated, I poured upon it diſtilled vinegar; put the whole in a warm place; ſaturated the acetic acid with cauſtic ammoniac; and, laſtly, filtered the mixture. What remained of the fluid ſuffered no alteration, either by carbonat of ammoniac, or by carbonat of ſoda. The *aluminous earth*, now obtained in a ſtate of purity, was firſt dried, then ignited, and found to weigh 31¼ grains.

Therefore, the conſtituent parts of *one hundred* grains of *Peruvian emerald*, here decompoſed, yielded:

Silex	*d*)	63½ grains	
	c)	4¼	
		67¾	
Subtract	*a*)	1½	
		66¼	66,25
Alumine, or argil	*f*)		31,25
Oxyd of iron	*b*)		0,50
			98

XXIX.

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XXIX.

CHEMICAL EXAMINATION

OF THE

BOHEMIAN GARNET.

THE denomination *garnet* ſerved to the elder Mineralogiſts as a generic, or *collective-name*, in which they included almoſt all roundiſh cryſtalline forms, encompaſſed by defined lateral facets, or all the ſpecies of ſtones, of, as they were called, a polyhedral cryſtallization. At preſent, however, the *generic name*, *garnet*, has been confined within narrower limits; for the *white* garnet, as well as the *black*, have been juſtly removed from it, and arranged as diſtinct genera: the firſt under the name *Leucite*; the ſecond under that of *Melanite.*

It may alſo be foreſeen, that ſeveral other foſſils now claſſed as ſpecies, or as varieties of the garnet, beſides thoſe laſt mentioned, will in time receive another place in the ſyſtematic arrangement of minerals: in conſequence of more accurate obſervations concerning the deviation, not only with regard to their external appearance, but likewiſe with regard to their chemical conſtituent parts, by which they are diſtinguiſhed from the true and ſtrictly determined principal genera, to which laſt the Bohemian garnet principally belongs.

The *Bohemian garnet*, (whoſe occurrence, method of procuring it from the mines, and external characters, are too well known to require any farther illuſtration in this place),

place), when weighed in water, loſt 269 parts of 1000 of its abſolute weight; its ſpecific gravity therefore is = 3,718.

It fuſes by itſelf alone in a proportionate intenſity of heat*. The iron which it contains is reduced to the reguline ſtate, when expoſed to the action of fire in the charcoal-crucible. From 100 grains of Bohemian garnet I obtained a button of iron, of 10⅛ grains weight.

In order to find out its conſtituent parts, I ſubjected it to the following experiments.

a) I ground *two hundred* grains of Bohemian garnet, previouſly pounded in the ſteel-mortar, with water, to a ſubtle powder, in the flint triturating diſh. When dried, and gently ignited, the powder of the ſtone was found increaſed in weight by ſeven grains. I inſpiſſated it with a lixivium, made of 600 grains of cauſtic pot-aſh, in a ſilver-crucible, and ignited it afterwards for half an hour. The ignited maſs was then ſoftened with water, lixiviated, and filtered. The filtered lixivium was of a light graſs-green, but ſoon loſt that colour, and became light-brown. By expoſure to a warm temperature, it depoſited, after 24 hours, an *oxyd of mangan͏eſe*, which, collected in a porcelain-cup, amounted to about half a grain. On fuſing it upon charcoal, with a neutral phoſphat, and covering it with nitrat of pot-aſh, the ſalt exhibited, after detonation, a dark violet-red colour, mingled with green ſpots.

b) The alkaline lye was then ſuper-ſaturated with muriatic acid, and evaporated nearly to dryneſs. After re-diſſolving the ſaline maſs in water, *ſiliceous earth* was depoſited, which weighed 11 grains, after edulcoration and ignition. When this had been ſeparated, ſome *aluminous earth* was thrown down by carbonated ſoda from the muriated ſolution. As the remaining liquor ſtill appeared of a yellow tinge, it was again evaporated to a dry ſalt. But this likewiſe had a citron-yellow colour, and again afforded a yellow ſolution with water; from which, however, nothing could be farther ſeparated, by any means whatever.

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* See Eſſay I. No. 39.

c) The lixiviated powder of the garnet had the colour of a light-brown iron ochre. To this I added the ſmall portion of alumine (*b*), and treated it with muriatic acid, with which it immediately formed a golden-yellow ſolution. When this laſt had been evaporated, in a ſand-heat, to a gelatinous conſiſtence; it was again largely diluted with water, once more digeſted and filtered. The *ſiliceous earth*, being well lixiviated, and heated to redneſs, weighed 76 grains.

d) Cauſtic ammoniac threw down from the muriatic ſolution a copious brown precipitate; which, after being collected on the filtering paper, was waſhed, and dried in a moderate warmth.

e) The colourleſs fluid, remaining after the precipitation with cauſtic ammoniac (*d*), was evaporated in part, and combined with carbonated ſoda. By this management, carbonat of lime fell down, which, after drying, weighed 12½ grains, equal to ſeven grains of *ignited calcareous earth*, or burnt lime.

f) I then divided the brown precipitate, obtained by means of ammoniac (*d*), into two equal parts.

One half of it I expoſed to ſtrong ignition in a covered crucible, and found, after this, its weight to amount to 55 grains.

g) The other half I diſſolved again in muriatic acid, diluted the ſolution with a ſufficient quantity of water, and precipitated its portion of iron by Pruſſian alkali. The ſeparation of the dark-blue precipitate being accompliſhed, I precipitated the ſolution, now freed from iron, by means of carbonated ſoda, and in a boiling heat. The quantity of the white, looſe earth thus obtained amounted, after waſhing, drying, and ignition, to 38½ grains.

From this it was manifeſt, that the proportion of *oxyded iron*, ſeparated by pruſſiated pot-aſh, amounted to 16½ grains.

h) The above 38½ grains of ignited earth (*g*), were then diſſolved in ſulphuric acid, and made to cryſtallize, after the addition of a proper quantity of acetated pot-aſh. The firſt ſhootings yielded regular cryſtals of alum. But the laſt ſhewed, by the oblong, four-ſided columnar figure of its cryſtals, that it was ſulphat of magneſia.

i) But as the ſulphat of magneſia could not be ſeparated from the alumine with ſufficient accuracy, I ſubjected the whole of the ſaline maſs to ſtrong ignition for an hour; after which I liquefied the ignited maſs with water, and combined the mixture, at a raiſed temperature, with powder of calcined oyſter-ſhells, added in ſmall portions, until the ſolution no longer reddened paper tinged with litmus. The filtered ſolution taſted now like pure ſulphat of magneſia; and, when ſet to cryſtallize, I obtained from it 69 grains of this neutral ſalt. However, on being re-diſſolved in water, it ſtill depoſited two grains of ſulphated lime: hence its true quantity amounted to 67 grains.

k) To recover from it the earth in a ſeparate ſtate, I precipitated the ſolution, in a boiling heat, by carbonat of ſoda.

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ſoda. The *magneſian earth*, waſhed and dried, weighed 23¼ grains; but when heated to incandeſcence in a covered crucible, and kept in that ſtate during half an hour, it weighed but 10 grains.

By ſubtracting theſe 10 grains of magneſia from the above 38½ grains (*g*), there remain 28½ grains for the aluminous earth.

One hundred grains of *Bohemian garnet* conſiſt, therefore, of:

Silex	*b*)	5½	
——	*c*)	38	
		43½	
and deducting	*a*)	3½	
		40	40,
Alumine	*k*)		28,50
Oxyd of iron	*g*)		16,50
Magneſia	*k*)		10,
Lime	*e*)		3,50
Oxyd of manganeſe	*a*)		0,25
			98,75

XXX.

CHEMICAL EXAMINATION

OF THE

ORIENTAL GARNET.

THE *Oriental*, or *Sirianic Garnet* *, is diſtinguiſhed from the *Bohemian*, both by its violet-red colour, and by its ſpecific gravity; which is = 4,085. This higher weight of it depends on the greater proportion of iron which it contains, and which is ſo conſiderable, that, by mere fuſion in the charcoal-crucible, I obtained from 100 grains of the oriental garnet a fine button of iron, of 23 grains. It likewiſe, when fuſed alone, in a crucible made of clay, runs into an enamel glaſs of a blacker colour than that of the Bohemian garnet †.

a) *Two hundred* grains of oriental garnet, previouſly bruiſed into ſmall pieces, in the ſteel mortar, acquired eight grains additional weight from the ſubſtance of the flint-grinding diſh, in which they were finely levigated with water. The powdered garnet was put in a cauſtic lye, in which the alkaline ingredient conſtituted thrice the weight of the powder; and, with this, it was inſpiſſated to a dry maſs, in a crucible made of ſilver. It was next ſubjected to red-heat during half an hour; and when the ignited maſs

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[*] Rather *Sirianic*, than Sirian garnet: from *Sirian*, a town in *Pegu*, now deſtroyed.

[†] See Eſſay I. No. 40.

had again been ſoftened with boiling water, the powder of the ſtone, ſeparated from the decanted liquor, was lixiviated and dried.

b) The alkaline lixivium was of a bright graſs-green. But it was ſoon deprived of that colour by expoſure to a warm temperature, at the ſame time that it depoſited an *oxyd of manganeſe*, impregnated with iron, in a brown flocculent form, and weighing about ½ grain when ignited.

c) The alkaline lye was now devoid of all colour. It was ſaturated with muriatic acid, and evaporated in part. A light flocculent earth then ſeparated, but part of it diſſolved again upon ſuper-ſaturation with muriatic acid. The inſoluble reſidue conſiſted of *ſiliceous earth* of 9½ grains after ignition. That part of the earth, which had been re-diſſolved by the exceſs of acid, was then ſeparated afreſh by carbonat of pot-aſh. After ignition, this earth weighed 4½ grains; and, upon being tried by ſulphuric acid, it proved to be pure alumine, or *aluminous earth*.

d) The edulcorated powder of the ſtone (*a*), which had a cinnamon colour, and a very incoherent form, was moiſtened with water, and treated with muriatic acid, in which it rapidly diſſolved, without leaving any reſidue. The liquor was limpid, and of a golden-yellow. But, on being ſubjected to evaporation, on a ſand-bath, it coagulated into a ſemi-tranſlucid, gelatinous ſubſtance; which had a deep golden-yellow colour, and was again digeſted for a while along with water that was poured upon it, and with repeated ſtirring. When, after this, it had been brought upon the filter, it left *ſiliceous earth* in a ſwelled ſtate; which, being thoroughly edulcorated by a frequent affuſion of hot water, and deſiccated, weighed 104 grains, but only 70 grains when heated to redneſs.

e) To

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e) To the muriatic ſolution, diluted with the waſhings of the ſilex (*d*), I added cauſtic ammoniac in exceſs. It gave a copious brown-red, much intumeſced precipitate, the quantity of which, after waſhing and drying, amounted to 190 grains.

f) The colourleſs fluid remaining from this laſt proceſs was firſt combined with as much muriatic acid as was requiſite to ſaturate the predominant portion of ammoniac, and then with carbonated ſoda. But as this produced no turbidneſs, I evaporated the whole of the liquor to a dry ſaline maſs, which being re-diſſolved in a little water, I tried it once more with carbonat of ſoda. The mixture ſtill continuing clear, ſhewed, that it contained no other conſtituent part.

g) Thoſe 190 grains of the brown-red precipitate, obtained at (*c*), were divided into two parts.

One half was ignited, and then found to weigh 61 grains. I poured upon it ſulphuric acid, evaporated it to dryneſs; and after having ſtrongly ignited the ſaline maſs for two hours, in a melting pot, I extracted it with water, and combined the filtered, clear fluid with carbonated ſoda, in a heat of ebullition. There ſeparated, however, ſome ſcarcely perceptible flocculi of aluminous earth only, without any trace either of lime, or of magneſia.

h) The other half of the precipitate was diſſolved in muriatic acid; and, after ſufficient dilution with water, combined with Pruſſian alkali, added ſucceſſively, till all the ferruginous parts were ſeparated. The blue precipitate of iron weighed 185 grains, when waſhed and deſiccated. After being ſtrongly ignited in a covered crucible, there remained 72 grains of iron attractible by the magnet. One part

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part of it was aſſayed for manganeſe by fuſion with a phoſphated alkali; but it gave no indication of this metal.

i) The ſolution being now freed from the iron (*h*), it was decompoſed in a boiling heat, by carbonated ſoda, and the precipitated earth lixiviated, and heated to redneſs. It weighed 25 grains; whereby, ſubtracting it from the 61 grains, obtained from the firſt half of the precipitate (*e*, *g*), the portion *of iron*, contained in 100 grains of this garnet, is found to be 36 grains.

k) When the above 25 grains of ignited earth (*i*) had been diſſolved in ſulphuric acid, and, after the addition of acetated pot-aſh in due proportion, was ſet to cryſtallize, they afforded to the end cryſtals of pure *ſulphat of alumine.*

It reſults from this decompoſition, that the conſtituent parts of the *oriental garnet* are in *the hundred:*

Oxyd of iron	*i*)		36
Silex	*c*)	4¾	
——	*d*)	35	
		39¾	
Subtract	*a*)	4	
		35¾	35,75
Alumine	*c*)	2¼	
——	*k*)	25	
——		27¼	27,25
Oxyd of manganeſe	*b*)		0,25
			99,25

XXXI.

CHEMICAL EXAMINATION
OF
VESUVIAN.

FIRST SECTION.

Veſuvian, from the Mountain Veſuvius.

AMONG the different ſorts of ſtones, which the Mountain Veſuvius brings up from the bowels of the earth, in their native unaltered ſtate, that cryſtalline foſſil may be reckoned, which the inhabitants of Naples call the *Veſuvian gem.*—Mineralogiſts had variouſly claſſed it with ſhörl, chryſolite, hyacinth, topaz, &c. and by the adjective, *veſuvian*, or *volcanic*, diſtinguiſhed it as a variety of the above mentioned gems; till *Werner* eſtabliſhed it as a diſtinct genus of ſtones, and gave it the name, *Veſuvian*; as, till then, it was found on Mount Veſuvius only.

An oryctognoſtic deſcription of that foſſil is already met with in various elementary treatiſes on mineralogy. That given by *Eſtner* * is particularly accurate and complete, for which reaſon I direct the reader chiefly to it.

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* *Eſtner, Verſuch einer Mineralogie für Anfänger und Liebhaber.* II. Band. Seite 177 ſeq.

A.

Examination in the dry way.

a) A ſmall piece of veſuvian, if ignited upon charcoal before the blow-pipe, gradually rounds itſelf into a dark-brown, ſhining, opake-globe, tranſparent only in ſplinters.

Borax (borat of ſoda) diſſolves it by degrees, to a clear light brown, and ſomewhat bliſtered, or air-bubbled glaſs-button.

It is not, however, completely diſſolved by means of a neutral phoſphat, for this only envelopes the particles of the foſſil, in the form of an amorphous frothy ſcoria.

The habitude of veſuvian is more remarkable, when acted upon by a greater intenſity of heat in the charcoal-crucible, which I have already communicated in the *firſt of theſe eſſays, page* 32, *n.* 103. The regular group of cryſtallization, there deſcribed, of the tender cruſt that ſurrounds the fuſed veſuvian, is a phenomenon according to my experience, the only one of its kind; and repeated experiments have convinced me that it is conſtantly the ſame.

B.

Examination in the humid way.

To decompoſe the veſuvian in the humid way, I picked out the beſt cryſtallized pieces of that variety which had a brown colour, inclining to olive-green. Theſe were coarſely powdered, and, by elutriation, freed from the greeniſh-white and delicate lamellas of chlorite and mica, which ſtill adhered. Placed upon the hydroſtatic balance, in this purified ſtate, its ſpecific gravity was 3,420.

a) *Hundred* grains of it were reduced to an impalpable powder, by levigation with water in the flint-triturating diſh. After gentle ignition, its weight was found to have encreaſed half a grain. Cauſtic alkaline lye, containing 300 grains of the ſalt, was then affuſed upon it, in a ſilver pot; and the mixture being firſt deſiccated in a ſand-heat, was next ſubjected to ſtrong ignition, during half an hour. Shortly before ignition the maſs acquired a vivid, light, graſs-green colour, but which was afterwards moſtly changed into a dirty olive-green.

b) The ignited maſs, while yet warm, was ſoftened with water, and thrown upon the filter. The filtered lixivium appeared of a pale greeniſh hue, but ſoon grew feebly brown-red. During gentle digeſtion, there ſubſided looſe, dark-brown, flocculent particles, leaving the lye colourleſs. As it could be foreſeen that they would not well ſeparate from the filtering paper, I collected them in a ſmall porcelain veſſel, and dried them after edulcoration. By this treatment I obtained a dirty-brown powder, conſiſting of ¼ grain of *oxyd of manganeſe*. When conveyed into fuſed phoſphoric ſalt, it diſſolved in it clearly. The glaſs-globule, thus formed, became by turns colourleſs and amethyſt-red, accordingly as I directed on it the inner or the outer point of the flame.

c) Upon the pale-brown, looſe veſuvian powder, ignited with cauſtic alkali (*a*), edulcorated and dried, I poured muriatic acid; which diſſolved it, with a little efferveſcence, and left ſome *ſiliceous earth* behind.

d) The yellowiſh ſolution, together with the waſhings when reduced in bulk by evaporation, formed a clear coagulum of a full golden-yellow. By diluting it again with much water, and digeſting it for ſome time under repeated agitation, the *ſiliceous earth* was rendered diſpoſed to ſeparation; I then collected it on the filter, and having added the foregoing portion (*c*), I ignited them both. They weighed together 36 grains.

e) Having thus freed the muriatic ſolution from all its ſilex, I added to it cauſtic ammoniac in a greater quantity than its ſaturation required, and immediately gathered on the filter the ſwelled precipitate thereby produced; which, upon being perfectly lixiviated, was conveyed into a cauſtic alkaline lye. It ſoon diſſolved in it upon the fire, leaving, however, a looſe, brown-red, muddy ſubſtance behind.

f) Both alkaline lixivia, that of (*e*), and that of (*b*), were then mixed, and over-ſaturated with ſulphuric acid, till the earth, firſt thrown down by the acid, was again diſſolved. Upon this I precipitated the earth by carbonated pot-aſh, edulcorated and re-diſſolved it in freſh ſulphuric acid, adding then a ſmall portion of acetated pot-aſh, and prepared the ſolution for cryſtallization. It yielded cryſtals of alum to the end, which I re-diſſolved in water, and precipitated its earthy portion by pot-aſh. The *aluminous earth* here obtained, when waſhed and ignited, weighed 19¼ grains.

g) That fluid, which remained on the precipitation, effected by cauſtic ammoniac (*e*), was then concentrated by evaporation, and mixed with carbonated ammoniac. Sixty grains of *crude calcareous earth*, or carbonat of lime, fell down, which, in the ignited or pure ſtate, are equal to 33 grains.

h) The

b) The brown reſidue, remaining from the ſolution of the argillaceous precipitate, in the cauſtic lye (*e*), was found to weigh 13 grains upon exſiccation. Muriatic acid was poured upon one half of it, and completely diſſolved it. Pruſſiat of pot-aſh, which was next added, produced a quantity of Pruſſian blue, of a pure deep colour. Carbonated ammoniac poured into the liquor, ſeparated from this laſt, ſtill precipitated ſome aluminous earth, weighing 1 grain after ignition. The ſecond half of that brown reſidue weighed five grains after expoſure to red-heat. From this it followed, that for the above-mentioned 13 grains of reſidue, we muſt reckon 7½ grains of ignited *oxyd of iron*, and 2½ of ignited aluminous earth. Some experiments made with that oxyded iron, to detect whether it contained manganeſe, evinced it to be abſolutely free from this ingredient.

Hundred parts of *veſuvian* from Mount *Veſuvius*, therefore, contain:

Silex	*d*)	36 grains.	
Subtract	*a*)	½	
		35½	35,50
Lime	*g*)		33
Alumine	*f*)	19¾	
——	*b*)	2½	
		22¼	22,25
Oxyd of iron	*h*)		7,50
Oxyd of manganeſe	*b*)		0,25
			98,50

SECOND SECTION.

Veſuvian from Siberia.

THE foſſil, which I here introduce by that name, belongs to the diſcoveries, as yet little known, made in Siberia, a country,

country ſo extenſive and abundant in remarkable mineral ſubſtances. It was diſcovered in the year 1790, by *Laxmann*, at the mouth of the river *Achtaragda*, where it falls into the ſtream *Wilui*. The firſt notice of it has been given by *Pallas* *, under the name *Cryſtals of Hyacinth*, together with a delineation of ſome of theſe cryſtals, added to their deſcription.

Their external colour is a dark olive-green, which, in the interior ſurface, paſſes into the brown of *colophony* (the reſidue of diſtilled turpentine). Their form is a rectangular four-ſided column, with truncated edges; yet the facets of the truncations are ſometimes ſo large, that the cryſtals might almoſt be called eight-ſided priſms.

In the entire cryſtals both ends of the column are ſharpened off to a quadrilateral pyramid. The points, however, are more or leſs, and in part, very much truncated.

As to the ſize of theſe cryſtals, the breadth of the column, in the ſpecimens which I poſſeſs, is from ½ to ¼ of an inch; and the length, not meaſuring the pointed termination, from ½ to a whole inch.

The external luſtre is but moderate; the internal is brighter, and partaking of the greaſy gloſs. The fracture is of the imperfect, ſmall conchoidal kind, and diſtinctly exhibits, eſpecially the longitudinal one, a foliated texture.

This foſſil is opake in its entire cryſtals; but its fragments are tranſparent, and even ſemi-pellucid.

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* Pallas *Neue Nordiſche Beyträge*, vol. v. Petersburg and Leipzig, 1793, page 282.

The

The gangue conſiſts of a pale, greeniſh-grey, dull ſtone, which ſeems to be of the ſerpentine kind; and in which thoſe cryſtals are ſingly imbedded.

Of one of thoſe cryſtals, whoſe abſolute weight was 253 grains, I found the ſpecific gravity to be 3,365; that of another, weighing 188 grains, was 3,390.

On ſome of thoſe cryſtals there are obſerved ſmall, opake, inſulated grains, formed like garnets, and of a greeniſh or yellowiſh-white colour. Some of theſe adhere but looſely; but others are more deeply concreted with the body of the cryſtals; yet, notwithſtanding this, they may be eaſily ſeparated, though they leave a cavity on the ſurface fitting their figure and ſize. When fuſed before the below-pipe, they run into a dark-brown ſmooth globule.

It has already been remarked by *Pallas* *, that this foſſil highly reſembles the veſuvian of Italy; and this agreement has been more determined by *Eſtner* †, on the ground of the external characters of both. This oryctognoſtic conjecture has been confirmed by the following chemical examination.

A.

Examination in the dry way.

a) The veſuvian from Siberia, either when ignited by itſelf, upon charcoal with the aſſiſtance of the blow-pipe, or when fuſed, under the ſame circumſtances, with *glaſs of borax*, or with a *neutral phoſphat*, ſhews, in every reſpect, the ſame relations as that from Mount Veſuvius, treated of in the foregoing ſection.

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* *Loc. cit.*

† *Verſuch einer Mineralogie*, vol. II. page 184.

b) One piece of it incloſed in the charcoal-crucible, and committed to the fire of the porcelain-furnace, fuſed to an aſh-grey, denſe, vitreous globe of a groſs-conchoidal fracture, and pellucid in thin fragments, the external ſurface of which was beſet with numerous grains of iron.

But I have not perceived, on this globe, any diſtinct trace of that cryſtalline cruſt, by which the Italic veſuvian, if fuſed in the ſame manner, is rendered ſo peculiarly remarkable.

B.

Examination in the humid way.

a) *One hundred* grains of the above foſſil, taken from a perfectly pure cryſtal, were finely pulverized with water in the flint-grinding diſh. Their weight increaſed half a grain. When inſpiſſated with a ſolution of 300 grains of cauſtic pot-aſh, and afterwards ignited for half an hour, a pale-greeniſh maſs was produced, inclining here and there to the browniſh, which, lixiviated with water, left a light-grey powder upon the filtering paper.

b) The lye, recently filtered, had a pale, dirty-browniſh colour, but it ſoon became colourleſs; and, at the ſame time, that ſome few browniſh flocculi were depoſited, which, undoubtedly, were *oxyded mangane*ſ*e*, but could not well be collected and examined, from their very minute quantity. When that lixivium had been neutralized with muriatic acid, aluminous earth fell down, which a ſlight exceſs of that acid has again entirely diſſolved.

c) The undiſſolved reſidue of the alkaline ſolution (*a*) was digeſted with muriatic acid. There remained ſome *ſiliceous earth*, which I ſeparated. Cauſtic ammoniac was then added in exceſs to the yellow ſolution, which had been mixed with the preceding (*b*), and it threw down a very intumeſced light-brown precipitate, the ſeparation of which was accompliſhed in an inſtant.

d) That precipitate, duly waſhed, and while yet moiſt, I digeſted with cauſtic alkaline lye. It was but ſlowly diſſolved in this menſtruum, and left a reſidue, the great volume and ſlimy appearance of which indicated, that it could not conſiſt merely of oxyded iron, but was ſtill mixed with ſilex. For this reaſon, I digeſted it with dilute muriatic acid, and evaporated it to a thickiſh maſs; which, being again diluted with water, depoſited the *ſiliceous earth* contained in it.

e) Cauſtic ammoniac, added to this ſolution, now free from all ſilex, again produced a brown paſte-like precipitate, that readily diſſolved in cauſtic lye, leaving a brown flocculent *oxyd of iron* behind, weighing 5½ grains when ignited.

f) To the alkaline lixivia of (*d* and *e*) an over-proportion of muriatic acid was added. They were then mixed with the muriatic ſolution (*b*), and together precipitated by carbonated pot-aſh, with the aſſiſtance of heat. The earth, thrown down by this treatment, was re-diſſolved in ſulphuric acid. There ſtill appeared ſome *ſiliceous earth*, after the ſeparation of which, the ſolution, by proper management, cryſtallized into pure alum. This being again diſſolved in water, I precipitated its *aluminous earth*, purified it afterwards by means of acetic acid and ammoniac, and when dried, I heated it to redneſs. It then weighed 16¼ grains.

g) What remained of the fluid, after the precipitation by cauſtic ammoniac (*c*), was evaporated to a part, and upon this combined with carbonat of ammoniac. Thus it afforded 62 grains of carbonat of lime, which are equal to 34 grains of pure *calcareous earth*.

h) The ſeveral portions of *ſiliceous earth* of (*c*, *d*, and *f*), when ignited and weighed together, amounted to 42½ grains.

It then reſults from this analyſis, that the conſtituent parts of the *veſuvian from Siberia* are preciſely the ſame as thoſe of the Italian. Only ſome variation takes place in their proportions, which, however, is no argument againſt placing them in the mineralogical ſyſtem as *two ſpecies*, or even merely as *varieties* of one *ſpecies*. For an *hundred* parts of the *Siberian* foſſil yielded:

Silex	*h*)	42½ grains.	
minus	*a*)	½	
		42	42
Lime	*g*)		34
Alumine	*f*)		16,25
Oxyd of iron	*e*)		5,50
Oxyd of mangane∫e	*b*)	a trace only.	
			97,75

XXXII.

CHEMICAL EXAMINATION OF *LEUCITE.*

FIRST SECTION.

THOUGH the foſſil at preſent known by the name *Leucite* or *Leucolite*, according to others, often occurs in *Italy*, (where it conſtitutes one of the ingredients not only in the lavas, the crude as well as thoſe that have been converted by volcanic fires into *tufas* and ſlag-ſand, or *volcanic aſhes*, but alſo of other mingled maſſes of rocks) yet there are but very ſcarce and uncertain indications of its exiſtence in other regions *. The *leucite* is remarkable by its very determinate ſpecific figure, which conſiſts of low, double octahedral pyramids, flatly ſharpened off to four terminating ſurfaces; ſo that it forms a roundiſh cryſtal, incloſed in 24 trapeziums.

Still leſs does that leucite ſeem to be known, which occurs in the rocks of Veſuvius, either in maſſes or in an indefinite form, variouſly mingled with black mica, black acicular ſhörl, hornblende, cryſtals of veſuvian, &c. and which hitherto has been moſtly conſidered as glaſſy felſpar, or granular quarz.

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* Of the foſſiſs foreign to Italy, and taken for leucite, that in particular will moſt probably be confirmed as ſuch on chemical examination, which Dr. *Reuſs*, ſo deſerving in the mineralogical hiſtory of his country, has found in Bohemia, and deſcribed. See his *Mineralogiſche Geographie von Böhmen.* Dreſden, 1797, vol. II. page 311—404.

The former denomination of this foſſil, *white garnet*, *Veſuvian garnet*, *garnet-ſhaped ſhörl*, is no longer to be retained, ſince the improvements made in *Oryctology*. On the other hand, *Werner* has aſſigned to it a peculiar place in the mineralogical ſyſtem, as a diſtinct ſpecies.

For the following analyſes I have ſelected only ſuch cryſtals of leucite ejected by Veſuvius, as, by their external appearance and internal luſtre, together with the yet unchanged ſtate of their ſtony matrix, (which is a black-grey corneous maſs of baſalt), have convinced me, that they had ſuffered no alteration either by volcanic fire, or by any ſubſequent decay. Moſt of them were of the ſize of a nutmeg and upwards. Before they were employed, they were freed as much as poſſible from the ſtony matrix adhering to their outſide, and likewiſe from the particles of hornblende uſually contained in their middle. In this purified ſtate their ſpecific gravity was 2,455.

A.

Examination in the dry way.

a) The leucite is completely infuſible, if ignited alone upon charcoal. It then undergoes no manner of ſenſible alteration, and its ſplinters loſe nothing of their luſtre.

b) If a ſmall fragment of it be put into fuſed borax, it is for a long time moved about in it before it diſſolves, which it does by degrees. The glaſs-globule, ariſing from thence, is clear and light-brown

c) By fuſion with a neutral phoſphat, the ſolution is ſtill ſlower, and a colourleſs rifty glaſs-pearl is produced.

d) One *hundred* grains of coarſely pounded leucite were expoſed for an hour to a ſtrong red-heat, in a ſmall porcelain-pot. The loſs of weight cauſed by this was only one-eighth of a grain.

e) Even the violent heat of the porcelain-furnace produced in the leucite only an inconſiderable change *.

B.

Examination in the humid way.

(1.)

a) *Hundred* grains of leucite, reduced to an impalpable powder, were ſeveral times digeſted in muriatic acid, which diſſolved a conſiderable part. There remained a *ſiliceous* reſidue, of 54 grains, after ignition.

b) This ſiliceous earth was then ignited with twice its weight of cauſtic alkali, ſoftened again with water, covered with muriatic acid, added to exceſs of ſaturation, and, after ſufficient digeſtion with this laſt, collected on the filter, and heated to redneſs. It was found to have ſuſtained, by this, a trifling decreaſe of weight.

c) On adding pruſſiat of pot-aſh to the muriatic ſolution, a precipitate enſued of ſo ſmall a quantity, as hardly to indicate one-eighth of a grain of *oxyded iron*. As, beſides, this ſlight portion of iron, probably, does not originate from the leucite itſelf, but from ſome particles of hornblende not perfectly ſeparable, I ſhall not conſider it among the conſtituent parts of that mineral.

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* See Eſſay I. No. 55.

d) Upon this I decompoſed the ſolution by cauſtic ammoniac; and, after having ſeparated the precipitate thus obtained, I tried the remaining liquor with carbonated ſoda, but no farther change was effected by it.

e) The precipitate produced by means of pure ammoniac (*d*) was firſt dried. It was next purified by digeſting it with diſtilled vinegar, and afterwards neutralizing this acid by ammoniac. It weighed 24½ grains, when edulcorated and ignited. Dilute ſulphuric acid completely diſſolved it to a limpid liquor, and when properly treated, the ſolution yielded only *alum*.

f) To obtain the earth, which poſſibly might have remained latent in the ſeveral waſhings, I evaporated theſe to dryneſs. After having re-diſſolved the ſaline maſs in water, I collected the portion of earth which ſtill appeared. However, it amounted only to half a grain, and was *ſiliceous earth*.

Therefore I obtained:

Silex	*a*)	54	
——	*f*)	½	
		54½	54,50
Alumine	*e*)		24,50
			79
		Loſs	21
			100

(2.)

This conſiderable loſs, in the ſum of the weights of the ſeparated conſtituent parts of the leucite, during this analyſis,

lyſis, has induced me to repeat the experiment with ſome variation in the proceſs.

a) One *hundred* grains of leucite were finely ground, and ignited during half an hour, with twice their weight of cauſtic pot-aſh. To the maſs, again ſoftened with water, muriatic acid was added, to juſt the quantity neceſſary for ſaturation. When the mixture had been filtered, I edulcorated and dried the remaining undiſſolved powder of the ſtone.

b) The leucite, thus prepared for decompoſition, was then extracted, in a boiling heat, by means of muriatic acid. There ſeparated ſome *ſiliceous earth*, which weighed 54½ grains after having ſuſtained a red-heat.

c) The muriatic ſolution was concentrated by evaporation, and tried by oxalat of pot-aſh; but no precipitation nor turbidneſs enſued. After this I recovered the *aluminous earth* in its pure and ſeparate ſtate, by the ſame means as employed in the preceding experiment. Its weight, after ignition, likewiſe correſponded, to within a trifle, with that of the firſt analyſis. It alſo ſhewed, upon farther trial, by re-agents, that, except an unimportant trace of oxyded iron, it was not in the leaſt mixed with any other earth, of whatever kind.

d) In the ſame manner, nothing more, of an earthy nature, could be obtained from the edulcorating waters by evaporation.

SECOND SECTION.

This agreement of the reſults of theſe two analytical reſearches increaſed my uncertainty where to look for the cauſe of that loſs of weight. At the ſame time it gave additional ſtrength to the conjecture, long ſince entertained by me, that in the mixture of foſſils, beſides the conſtituent parts, found by analyſis, there might be preſent other component principles, which have hitherto eſcaped diſcovery. That chemical decompoſitions of bodies, even when inſtituted with all poſſible care, are attended by ſome loſs, is founded on the nature of the ſubject itſelf. However, the above loſs was too great to be included in that which is abſolutely unavoidable. It is, indeed, the ſhorteſt way to get over the difficulty, if the loſs in the ſum of the weight of the ingredients, although of ſome importance, is accounted for ſimply by the air and particles of water expelled. But ſuch an explanation would by no means be capable of ſatiſfying me in the preſent caſe.

I was fully convinced, that, in thoſe proceſſes, at leaſt no earthy, or any other component part, ſoluble in water, had been loſt. It was likewiſe evident, from the experiments related in the beginning of this eſſay, that neither *water* nor *carbonic acid* was to be ſought for in leucite. For theſe reaſons, I proceeded to other experiments, which tended to try that foſſil, for the *phoſphoric*, *fluoric*, and *boracic* acids; but of none of theſe I could diſcover any ſign.

On the contrary, I was ſurpriſed in an unexpected manner, by diſcovering in it another conſtituent part, conſiſting of a ſubſtance, the exiſtence of which, certainly, no one perſon would have conjectured within the limits of the mineral kingdom, and, leaſt of all, in the natural mixture of a ſolid foſſil, which, in a *mineralogical ſenſe*, is ſimple or unmixed.

This conſtituent part of leucite, which now appears in the character of an oryctognoſtic or mineral ſubſtance, is no other than *pot-aſh*, which, hitherto, has been thought *ex-*

cluſively to belong to the *vegetable kingdom*, and has, on this account, been called VEGETABLE ALKALI.—This diſcovery, which I think of great importance, cannot fail to occaſion conſiderable changes in the ſyſtems of natural hiſtory, till now eſtabliſhed, and will ſerve to illuſtrate various phenomena in the mineral as well as in the vegetable kingdom.

The following experiments will ſhew the particulars.

(1.)

a) *Two hundred* grains of finely triturated leucite were extracted, by repeated digeſtion with muriatic acid. The ſiliceous earth, collected on the filter, and lixiviated, weighed 109 grains after ignition.

b) The muriatic ſolution had a yellowiſh colour. When evaporated in a ſand-heat, to the conſiſtence of honey, I obſerved its ſurface covered with a pretty ſtrong ſaline cruſt. After complete cooling, the maſs appeared like a thick, golden-yellow, clear oil, full of cryſtals, partly of a cubical, partly of a tabular form. I gently poured off the yellow fluid, and rinſed the ſalt with ſmall portions of alkohol. The ſolution, diluted with alkohol, was then evaporated afreſh, and the ſmall quantity of ſalt, which it afforded, again waſhed with ardent ſpirit, and added to the firſt. The ſalt thus obtained, and highly deſiccated, weighed 70 grains. This I diſſolved in water, adding ſome drops of ammoniac, which ſtill ſeparated ſome particles of aluminous earth. The ſolution was then again made to cryſtallize in a warm place, and it afforded only cubical cryſtals, ſome of which were lengthened to quadrilateral columns.

c) That portion of the muriatic ſolution, which would ſhoot into cryſtals, was diluted with water, and decompoſed

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in a boiling heat by carbonated ſoda. The precipitate conſiſted of aluminous earth, weighing 47¾ grains, when depurated, waſhed, dried, and ignited. Upon this I poured three times its weight of concentrated ſulphuric acid, and evaporated the mixture to a moderate dryneſs. The maſs re-diſſolved in water, then combined with a ſolution of acetated pot-aſh, and ſet to cryſtallize, ſhot entirely into alum.

d) I mixed the ſiliceous earth, obtained at (*a*), with double its weight of pot-aſh, and kept it in a ſtrong red-heat for the length of one hour. The maſs, which had but moderately coaleſced, was ground, diluted with water, ſuperſaturated with muriatic acid, and digeſted. By ſaturation with mineral alkali or ſoda, the filtered muriatic ſolution ſtill afforded 1½ grain of *aluminous earth*; which being ſubtracted from the firſt weight of the *ſiliceous earth* (*a*), there remainded, for this laſt, 107½ grains.

From thoſe decompoſed 200 grains of leucite have, conſequently, been obtained:

Silex :	*d*)	. . . . . ,	107,50
Alumine	*c*)	47¾	
———	*d*)	1½	
		49¼ . . .	49,25
			156,75

Hence there were ſtill wanting . . . . . 43,25 grs.
To account for which, I was to direct my attention to the 70 grains of ſalt mentioned at (*b*).

With a view of diſcovering its baſis, I ſubjected it to the following trials:

1.) Its taſte and the figure of its cryſtals were found to be preciſely the ſame with thoſe of muriated pot-aſh, or digeſtive ſalt, as it is termed.

2.) No change was effected either in the blue, or in the reddened litmus paper, by its ſolution.

3.) It made a crackling noiſe, when heated to redneſs, and remained behind as a body fixed in the fire.

4.) Its ſolution was not rendered turbid, either by carbonated ſoda, or by cauſtic ammoniac.

5.) Having poured *two* parts of ſtrong ſulphuric acid upon *three* of that ſalt, I cauſed the muriatic acid to evaporate, by means of heat, re-diſſolved the maſs in water, and obtained ſulphat of pot-aſh (vitriolated tartar) in its uſual cryſtals.

6.) The portion of ſalt which yet remained I diſſolved in a little water, and treated it with a concentrated aqueous ſolution of pure cryſtallized acid of tartar. *Cream of tartar*, or acidulous tartarite of pot-aſh, was, by this management, immediately produced, which fell to the bottom in the form of ſand. This was waſhed, dried, and burnt in a ſilver crucible; and when the coal which it produced was lixiviated, and the clear lixivium evaporated to a dry ſalt, it proved by every teſt that was applied to be a *carbonat of pot-aſh*. By ſaturation with nitric acid, it ſhot into priſmatic nitre, (nitrat of potaſh).

Therefore, the baſis of thoſe 70 grains of ſalt conſiſted ſolely of pure vegetable alkali, which had been neutralized by a proportionate part of the muriatic acid employed in the compoſition of the foſſil. If now, as *Bergmann* aſſerts, the alkaline baſis of muriated pot-aſh amounts to 61 parts in an hundred of the compound, the above mentioned 70 grains (*a*) contained 42,7 grains of pot-aſh. And thus the 43,25 grains, before wanted to make up the 200 grains of leucite analyſed, are accounted for to within a trifling deficiency.

Conſequently by the reſults of this analyſis, accompliſhed by muriatic acid, *hundred* parts of leucite conſiſt of:

Silex	53,750
Alumine	24,625
Pot-aſh	21,350
	99,725

(2.)

a) *Three hundred* grains of leucite, reduced to a moſt ſubtle powder, were repeatedly digeſted, by boiling with four ounces of nitric acid. The *ſiliceous earth*, when ſeparated by filtration, and ignited, weighed 162½ grains.

b) This nitric ſolution was next evaporated. At firſt it continued colourleſs; but towards the end it turned a little yellowiſh, and after refrigeration it appeared like clear, tenacious turpentine. When diluted with water, and evaporated to but a moderate degree, it congealed into a greaſy ſaline maſs, conſiſting of ſmall priſmatic cryſtals. It was then ſucceſſively treated and waſhed with alkohol, until the ſalt remained in a purified ſtate. To the ſolution of this ſalt in water a few drops of ammoniac were added; to free it from a ſlight portion of earth which ſtill adhered,

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and which was thus thrown down, and afterwards collected on the filter. After this, the whole of the ſaline ſolution, which was now as limpid as water, by ſlow exhalation has ſhot into priſmatic hexahedral cryſtals, weighing 123 grains, after thorough deſiccation.

c) That portion of the above nitric ſolution, which remained mixed with the ſpirit of wine, and refuſed to cryſtallize, was diluted with water, and, in a boiling ſtate precipitated, by the addition of carbonated ſoda. The earthy ingredient fell down in a ſlimy, ſwelled form.— This, when previouſly waſhed and diſiccated, together with the foregoing ſlight portion of earth (*b*), was treated with diſtilled vinegar, and kept for a while in a warm place. The acetic acid was then neutralized by cauſtic ammoniac; and the earth, precipitated afreſh, collected on the filter, again waſhed, dried, and ignited; in which ſtate it weighed 70¼ grains. It now preſented itſelf in the character of the moſt pure *aluminous earth*; for, when diſſolved by ſulphuric acid, combined with acetite of potaſh, and cryſtallized, it yielded nothing but ſulphat of alumine.

d) Having collected the edulcorating water, I concentrated it by evaporation, and treated it, while boiling, with mild ſoda. But no further precipitation took place.

e) The above mentioned 162½ grains of ſilex were mixed with twice their weight of effloreſced ſoda, and along with it ignited for two hours in a ſilver pot. Upon the maſs, when ſoftened with a little water, an overproportion of muriatic acid was added, and the whole, after ſome digeſtion, diluted with water, and thrown upon the filter. On ſaturating the muriatic fluid with ſoda, a yellowiſh white precipitate aroſe, which, after heating to redneſs, weighed two grains, and was *alumine*, coloured by iron. As theſe ſhould be ſubtracted, there are only 160¼ grains to be put in the account for the *ſiliceous earth.*

It then appears, that in this analytical proceſs, the alkaline-ſaline conſtituent ingredient in the leucite was neutralized with the requiſite quantity of nitric acid, and generated true nitre. But that the above conſtituent part is really and undoubtedly of the very ſame quality and nature with the vegetable alkali, has been evinced by the following examinations.

1.) The taſte and cryſtalline figure of this ſalt perfectly agree with thoſe of common nitre.

2.) When its ſolution had been combined with a ſolution of nitrated ſilver, or with that of acetated barytes, it continued bright and clear. This fact ſhews, that in the natural mixture of leucite, this alkaline-ſaline conſtituent part is contained, not accidentally and merely by the aſſiſtance of carbonic or ſulphuric acid, by which it may be neutralized, but rather in a perfectly pure ſtate.

3.) Upon a part of that ſalt I affuſed half its quantity of ſtrong ſulphuric acid, and carried on its evaporation until the nitric acid had been totally expelled. And when, after this, the reſidue had been re-diſſolved in water, and cryſtallized, it produced ſulphat of pot-aſh in its uſual cryſtalline form.

4.) The portion that remained I introduced into a ſmall porcelain-veſſel, and heated it to fuſion, adding by degrees powdered charcoal in ſmall portions, as long as any detonation took place.—The ſaline maſs remaining conſiſted of *carbonated pot-aſh:* and upon ſaturating it anew with ni-

tric

tric acid, it formed again priſmatic *nitrat of pot-aſh*; in the ſame manner, as *vitrialated tartar* was produced from it by means of ſulphuric acid, and *digeſtive ſalt* by means of the muriatic.

Concerning the alkaline baſis of nitre, I ſhall take for a ſtandard the proportion ſtated by *Bergmann*, according to which 100 parts of priſmatic nitre contain 49 of vegetable alkali. With this, likewiſe, *Wenzel* very nearly agrees, as he reckons 48⅛ of pot-aſh in 100 of nitre, and this ſmall difference probably depends on this circumſtance, that the latter weighed his nitre in the ignited ſtate. As, therefore, upon this ground of calculation, the above mentioned 123 grains of nitre (*b*) contain 60,27 grains of vegetable alkali, the proportion of the conſtituent parts in 300 grains of decompoſed leucite are as follow:

Silex	*e*)		160,50
Alumine	*c*) . .	70¾	
———	*e*) . .	2	
		72¾ . .	72,75
Pot-aſh			60,27
			293,52

Or in *one hundred*:

Silex	53,50
Alumine	24,25
Pot-aſh	20, 9
	97,84

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(3.)

I attempted alſo the reſolution of leucite into its principles, by means of *ſulphuric acid.*

a) *Two hundred* grains of finely pulverized leucite were evaporated nearly to dryneſs, in a mixture of 200 grains of concentrated ſulphuric acid with double its quantity of water. From the maſs, again liquefied with water, the *ſiliceous earth* was ſeparated by filtering. It weighed 59 grains, and ſhewed by this, that it ſtill contained ſome grains of undecompoſed leucite.

b) The colourleſs ſolution afforded, by evaporation, a clear, tenacious maſs; which, when again diſſolved in water, preſently ſhot, without any further addition, into regular ſulphat of alumine, weighing 128 grains.

c) This alum I expoſed to a red-heat, and boiled the reſidue, previouſly powdered, with water; ſubtracting at the ſame time the predominant part of the acid, by ſaturation with powdered oyſter-ſhells. The filtered and clear ſolution, being upon this evaporated, ſo as to cryſtallize, gave *ſulphat of pot-aſh.*

d) The remainder of the ſulphuric ſolution (*b*) has congealed, on farther evaporation, into a greaſy, finely radiated maſs.

THIRD SECTION.

In all the preceding experiments the leucite from *Veſuvius* alone was employed. But as leucites are found in various other parts of *Italy*, it was an intereſting point for me to

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learn, whether, and how far, the conſtituent parts of theſe laſt agree with thoſe of the foregoing.

With this view, I ſelected the leucite of *Albano*, near *Rome*.* The ſpecimens I have obtained of it conſiſt of ſolitary grains, of the ſize of green or ſweet peaſe, and larger. Their exterior colour is a yellowiſh-white, and their cryſtalline figure is for the moſt part indiſtinct, owing to the edges and angles being worn off by friction; whereas the Veſuvian leucite is externally dull, and of an aſh-grey, and commonly occurs with uninjured angles and edges.—The leucite from *Albano*, on the contrary, is clearer, more tranſlucid, and more free from hornblende, in its interior maſs, than that from Mount Veſuvius.

I found its ſpecific gravity to be 2,490.

a) An *hundred* grains of leucite from *Albano*, in a fine pulverulent ſtate, were boiled with muriatic acid, and left behind them undiſſolved *ſiliceous earth*, which, after ignition, amounted to 54 grains.

b) The muriatic ſolution was next evaporated to dryneſs on a ſand-heat, and the yellowiſh-white reſidue, covered with alkohol, was expoſed to a warm temperature, in a high cylindrical glaſs. After it had cooled, I decanted the ſpirituous ſolution of the muriated alumine from the muriat of pot-aſh, which lay at the bottom as a white cryſtalline powder;

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*) I acknowledge my thanks for the communication of this, and a great part of the foregoing leucite to *Count Lepel*, and Dr. *Thompſon*, of Naples. It was by this augmentation of my little ſtock of this foſſil that I was enabled to carry my analytical proceſſes to complete evidence.

powder; and when the alkohol had evaporated in a warm temperature, I diſſolved again the reſidue in ardent ſpirit, and added the ſmall portion of muriated pot-aſh, which ſtill ſubſided, to the preceding. The whole quantity of it obtained was 36 grains; of which, according to what has been ſaid before (page 357), 22 grains are *vegetable alkali*, conſtituting its baſis. By ſolution in water, and perfect purification by means of a few drops of ammoniac, and ſubſequent evaporation at a raiſed temperature, it ſeparated in pure cubic cryſtals. Theſe being re-diſſolved, and combined with acid of tartar, produced cream of tartar; which, after ignition and lixiviation, afforded *carbonated pot-aſh.*

c) The muriat of alumine, that was held in ſolution by the alkohol (*b*), was diluted with water, and decompoſed by ammoniac. The *aluminous earth*, thus precipitated, amounted to about 23 grains, when waſhed, dried, and ignited.

Theſe hundred grains of leucite from *Albano* were therefore reſolved into:

Silex	*a*)	54
Alumine	*c*)	23
Pot-aſh	*b*)	22
		99

FOURTH SECTION.

THE inferences reſulting from the above experiments might be in ſome degree queſtioned by thoſe philoſophers, who conſider the baſaltic matrix of leucite, as well as all baſalts in general, as lavas, and hence would think themſelves entitled to doubt the primitive origin of leucite, and the originality of its alkaline conſtituent part now diſcovered. Therefore, in order at once to obviate every poſſible objection, I reſolved to inveſtigate whether a leucite, the mixture of which muſt be acknowledged as not volcanized, even by the moſt obſtinate Volcaniſts, would contain pot-aſh in its natural mixture as a conſtituent part, though hitherto this alkali has been conſidered as belonging only to the vegetable kingdom. For this purpoſe, I ſelected that *irregularly ſhaped*, finely-grained, foliated *leucite*, mentioned at the beginning of this Eſſay, which either accompanies the ſtony maſſes, compounded of mica, ſhörl, veſuvian, calcareous ſpar, &c. that are ejected by Veſuvius in their original rough ſtate; or which is concreted with them. Of theſe ſpecimens, I ſeparated for this inquiry a ſufficient quantity of *leucite* in a lump or *maſs*, and performed its analyſis according to the method before deſcribed.

By the proceſs I obtained, beſides *ſilex* and *alumine*, a cubically cryſtallized muriated neutral ſalt, whoſe alkaline baſis ſhewed itſelf to be vegetable alkali, from the circumſtance of its producing cream of tartar, by combination with tartareous acid.

This enquiry into the conſtituent parts of that variety of leucite was ſatisfactory; though the determination of their *proportions* could not be accompliſhed with due accuracy, on account of the black needles of ſhörl, ſmall wax-yellow grains of veſuvian, and the like, with which it was too abundantly mixed.

FIFTH SECTION.

(1.)

As the preceding analyſes were all performed with thoſe ſpecies of leucite, which remained in their unaltered original ſtate, it remained to complete the ſubject by the examination of a leucite, which had ſuſtained the action of a *volcanic fire.*

The ſpecimen of leucite ſubjected to this experiment was picked up at *Pompeji*, and belongs to the moſt common varieties. It conſiſts of detached grains, for the moſt part of the ſize of a pepper-corn. Its interior ſurface, like the exterior, is aſh-grey, of an earthy appearance, and wholly opake; and it may be eaſily comminuted to a ſandy powder.

Hundred grains of it, decompoſed by muriatic acid, exactly in the ſame manner as the leucite from *Albano* in the third ſection, and the muriat of pot-aſh thereby obtained, calculated for its baſis of vegetable alkali, have afforded:

Silex	54,50
Alumine	23,50
Pot-aſh	19,50
	97,50

It remains for repeated experiments to decide, whether it is merely accidental, that the proportion of the alkaline ingredient, in this inſtance, is leſs than uſual; or whether this diminution takes place regularly in every leucite, altered by volcanic fire.

(2.)

In this place I ſhall, moreover, briefly notice a particular variety of leucite, which occurs at *Ronciglione.* It is found

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ſound of middle-ſized, inſulated grains, preſenting ſometimes traces of their original cryſtalline form. Thoſe grains are whitiſh, inclining to the iſabella-yellow; they are entirely opake, of an earthy look, and very eaſily friable. When thus comminuted, they do not yield ſuch a harſh ſandy powder, as is obtained from grains of volcanized leucite, but a ſoft powder reſembling argillaceous earth.—It ſeems, therefore, that they have not ſuffered any change by the fire; but have rather undergone a high degree of decay, cauſed by the joint action of water and air; and finally, that, by this alteration, they have been brought near to their complete ſpontaneous decompoſition, or reſolution into their component principles.

The ſtock which I had of them was too ſmall to admit of a complete examination; which, however, I think they deſerve, for the purpoſe of diſcovering, whether in this ſtate of great decay, they had ſuffered any loſs of that alkaline ingredient, which was before unknown in the mineral kingdom.

I now flatter myſelf with the hope, that, by the experiments here communicated, and ſeveral times repeated, I have fully demonſtrated the exiſtence of pot-aſh in the leucite, as one of its chemical conſtituent parts. Nevertheleſs, I am contented to defer the general reception of this new diſcovery till ſeveral other chemical naturaliſts have re-examined and confirmed it. This trial may be the ſooner expected, ſince my method of proceeding in the main object of this inveſtigation is attended neither with laborious operations, nor with much loſs of time.

But if that alkali, as ſoon as it can no longer be conſidered as a ſubſtance, produced only in the juices of plants during their vegetation, be required to occupy a more ſuitable place among the original, ſimple mineral ſubſtances, it will then likewiſe be neceſſary to give it a more appropriate name.

The term *Pot-aſh*, which, in the new chemical nomenclature, is raiſed to a *generic* name, cannot among us *Germans* claim a general acceptation; as its origin depends on a trivial *etymological* ground, and has been introduced into uſe merely from this circumſtance, that formerly, inſtead of calcining furnaces, iron *pots* were employed to ignite the inſpiſſated lyes procured from wood-aſhes.

I ſhould wiſh to recommend, that the denominations hitherto uſed, of *vegetable alkali*, *lixiviated vegetable ſalt*, *pot-aſh*, &c. be diſcarded, and the name KALI* be employed in their ſtead. In like manner ſhould the appellations, *mineral alkali*, *ſoda*, &c. denoting the alkaline baſis of common ſalt, give place to its ancient name, —NATRON.

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*) This has been done by the London Royal College of Phyſicians in the year 1787. They have introduced in their *Pharmacopœia* both theſe names, *kali* and *natron*, here recommended by *Klaproth*. The *Edinburgh Diſpenſatory*, on the other hand, calls the firſt *lixiva*, and the ſecond *ſoda*.—However, the terms, *pot-aſh* and *ſoda*, being at preſent more familiar to modern Engliſh chemiſts, the Tranſlator has, for the moſt part, given them the preference.—Tranſl.

XXXIII.

CHEMICAL EXAMINATION

OF

PUMICE-STONE.

THE *Pumice-ſtone* belongs to thoſe mineral bodies, on the origin and formation of which the opinions of philoſophers are yet divided. Various paſſages in the works of *Theophraſtus*, *Dioſcorides*, *Pliny*, and *Galen*, concerning this ſubſtance, ſhew ſufficiently, that, even in remoter ages, Naturaliſts have thought it worth their conſideration. One of the principal foundations abſolutely neceſſary to be laid down by the inquiring *Geogoliſt*, if he wiſhes to raiſe with ſucceſs the edifice of his theories, undoubtedly conſiſts in a juſt and accurate chemical knowledge of his object. This knowledge has, however, been hitherto wanting, with regard to pumice-ſtone. For, although various analyſes of it have been publiſhed, there ſtill occurs a very important difference in the enumerations of its conſtituent parts: ſo much ſo, that the Mineralogiſt is at a loſs to know, which of them he is to follow in the arrangement of foſſils.

Many of thoſe who have analyſed the pumice ſtone, conſider it, with *Bergmann*,* as an *asbeſt* changed in its mixture by a volcanic fire. This opinion ſeemed to be juſtified, partly by its fibrous texture, partly, and eſpecially, by the portion of magneſia, that has been ſuppoſed to exiſt in it. But, notwithſtanding that *Bergmann*, *Cartheuſer*[*], and but very lately *Spallanzani*[†], have mentioned the magneſian earth, in their analyſes of pumice-ſtone, as a conſtituent part,—I am convinced, by my own experience, that it does not, in the leaſt, enter into this foſſil. The ſuppoſed origin of pumice-ſtone from asbeſt is, therefore, unfounded; and, along with this falſe derivation, likewiſe, another difficulty of ſome weight is removed, which ſeemed to oppoſe the inſtructive theory of the *matrices of pumice-ſtone* given by *Noſe*[‡].

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* *Bergmann* Opuſc. Phys. et Chemic. vol. III. p. 197.

a) Common, grey-white, fibrous pumice-ſtone, ſwimming on water, and procured from *Lipari*, was ground, and boiled with water. The water boiled with it was found to have extracted nothing; only, by treatment with nitrated ſilver, it gave a ſlight indication of muriatic acid.

Hundred grains of this pumice-ſtone, gently ignited, and finely pulverized after decoction, were expoſed to a red-heat, with twice their weight of cauſtic alkali, during half an hour. The maſs returned from the fire of a bright graſs-green colour; by which it was found to contain a ſmall portion of *mangan:ſe*. After having been ſoftened with water, this colour changed to a foul light-brown. It was then digeſted with dilute muriatic acid. *Siliceous earth* ſeparated in this proceſs; which, collected on the filter, and finally heated to redneſs, weighed 77½ grains.

b) What had been diſſolved by the acid was next precipitated by cauſtic ammoniac, and the browniſh precipitate collected on the filter. The fluid ſeparated from it, contained no extraneous matter.

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[*] *Cartheuſer*, Mineralogiſche Abhandlungen, Th. II. p. 136.

[†] *Spallanzani*'s Travels into both *Sicilies*, vol. II.

[‡] *Orographiſche Briefe*, vol. II. page 185 and others. Alſo *Sammlung einiger Schriften über Vulkaniſche Gegenstände a. d.* Baſalt, page 271.

c) Hot cauſtic lye directly diſſolved that precipitate, leaving an *oxyd of iron* behind it, the quantity of which, after ignition, was 1¾ grains.

d) The alkaline ſolution, previouſly ſuper-ſaturated with muriatic acid, was combined with carbonated alkali. Thus, the earth which it held diſſolved was precipitated. When edulcorated, and heated to redneſs, it weighed 17½ grains. It proved to be pure *aluminous earth*; for, on being re-diſſolved in ſulphuric acid, and combined with an adequate portion of liquid acetated pot-aſh, it afforded nothing but alum.

In conſequence of this, the conſtituent parts, diſcovered in the common *pumice-ſtone from Lipari*, are:

Silex	*a*) . . .	77,50
Alumine	*d*) . . .	17,50
Oxyd of iron	*c*) . . .	1,75
Beſides a trace of *manganeſe*	*a*)	
		96,75

It is worth remarking the ſmall degree of ſolvent power which acids exert on rough pumice-ſtone. Although I had digeſted 100 grains of finely-ground pumice-ſtone with twelve times its quantity of muriatic acid, aſſiſted by a boiling heat, yet it was hardly attacked. The acid, indeed, was tinged of a faint yellow; however, at moſt, there appeared only a few looſe, browniſh flocculi, which, when moſt carefully collected, ſcarcely amounted to ⅛ of a grain, and conſiſted, for the greateſt part, of oxyd of manganeſe. The ſulphuric acid proved to be as little capable of affecting rough pumice-ſtone as the muriatic.

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XXXIV.

CHEMICAL EXAMINATION OF THE *TERRA AUSTRALIS* (*Sidney-earth*).

A few years ſince, the public has become acquainted with an arenaceous, or ſandy foſſil, under the name *Auſtral-ſand*, which has been found near *Sidney-cove*, in *New South-Wales*, and was brought from thence to England. This foſſil has been aſſerted to contain a new, diſtinct, peculiar earth, denominated *Auſtral-earth* (*Sidneia, Cambria*), upon the ground of its analyſis made and publiſhed by *Joſ. Wedgwood*[*]; of which the following are the principal particulars. The principal character of that earth is ſaid to be, that it reſiſts all acid and alkaline menſtrua, ſtrong muriatic acid only excepted, which alone, by means of repeated digeſtion, takes up this earth from that arenaceous foſſil. It is alſo ſaid to be again precipitated from its muriatic ſolution, merely by dilution with water; and to be, after this, abſolutely inſoluble in any other ſolvent but the muriatic acid, with the aſſiſtance of heat.

My deſire of acquiring information on this ſubject by my own experience has continued till now unaccompliſhed. It is only of late that I was fortunate enough to receive a quantity of auſtral-ſand; little, indeed, yet ſufficient for an examination ſparingly managed. The ſpecimens obtained were of two ſorts. One of them was mixed with a greater proportion of thoſe black, ſhining lamellæ, that are taken for graphite, but, to my conjecture, are rather flakes, or ſcales, of ferruginous mica. The other ſort was purer, and had leſs of the ſubſtance juſt mentioned. For this reaſon I employed only this in the preſent inquiry.

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[*] *Philoſophical Tranſactions*, vol. lxxx. 1790.

a) I triturated *thirty* grains of it to a moſt impalpable powder. The original grey-whitiſh colour of that foſſil changed thereby to a blueiſh, owing to a more minute diviſion of the particles of ferruginous mica. Strong muriatic acid was then affuſed upon the powder, and digeſted with it for a conſiderable time, in a heat of ebullition. After cooling, the acid was decanted from the ſediment, and this laſt digeſted with a freſh quantity of the ſame acid. This operation was reiterated a third time.

b) When the acid had been filtered clear, through a double-folded printing-paper, I diluted it gradually with a large quantity of water; but not the leaſt turbidneſs nor precipitation enſued. I expoſed the mixture to a warm temperature; yet ſtill it remained clear and limpid, like water.

c) The muriatic liquor was then ſaturated with carbonat of pot-aſh. This threw down a few light particles, which, collected on the filter, waſhed, and dried, weighed 3¼ grains. They alſo diſſolved in dilute ſulphuric acid, but left behind a ſlight portion of ſilex, and formed with that acid cryſtals of alum.

d) The reſidue left on the extraction with muriatic acid was ignited with three parts of carbonated pot-aſh, then again treated with muriatic acid, and its inſoluble ſlimy portion ſeparated by filtration. This laſt conſiſted of ſilex, weighing 19½ grains, when edulcorated and ignited.

e) The muriatic ſolution was then tried with pruſſiated pot-aſh. The blue precipitate hereby produced indicated about ¼ grain of iron.

f) By combining afterwards the ſolution with carbonated pot-aſh, aluminous earth was precipitated; which, after ignition, weighed 8½ grains, and, upon ſolution in ſulphuric acid, entirely cryſtallized into ſulphat of alumine.

Silex, *alumine*, and a little *iron*, therefore, were all the principles I was able to diſcover in the auſtral-ſand here examined; and no trace of any other conſtituent ingredient appeared.

Although in this inquiry I have been obliged to confine myſelf to the ſmall quantity of 30 grains, without being able to repeat it for want of a greater ſtock of this mineral, yet its reſult is ſufficient to excite a very reaſonable doubt of the *real exiſtence* of ſuch a new earth as is pretended to be met with in auſtral-ſand. Time will ſhew whether this doubt may be removed, or confirmed, by repeated and more accurate analyſes. If the laſt ſhould be the caſe, the illuſion which led to that erroneous ſuppoſition may, perhaps, be explained in the following manner:—

Mr. *Wedgwood* does not tell whether he had filtered, to perfect clearneſs, the muriatic acid employed for the extraction of the foſſil, and *previouſly* to its being mixed with water. The contrary ſeems rather to have taken place; for he ſays that the fluid turned white when he added water to the acid, for the purpoſe of diluting the acid, and edulcorating its remaining part. It is therefore probable that the earth, let fall by the acid on the admixture of water, was nothing elſe but alumine ſtill chemically combined with ſilex, which, during the long and hot digeſtion, had been taken up by the muriatic acid, and was now depoſited in the water.

Finally, that the foſſil here examined was *genuine auſtral. ſand*, is warranted by the hand from which I received it. It was Mr. *Haidinger*, from *Vienna*, who kindly gave it me on his return from London, where he obtained it from the Right Hon. Sir *Joſeph Banks*, Bart.*

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* Since that time *Charles Hatchett*, Eſq. F. R. S. of London, has likewiſe analyſed the *terra auſtralis*, and found it to contain *no new earth*, but to be a compound of ſilex, *alumine*, *oxyd of iron*, *and plumbago*. His paper is printed in the *Philoſophical Tranſactions* for the year 1798.—Tranſl.

XXXV.

CHEMICAL EXAMINATION OF THE *GRANULAR SULPHATED BARYTES*,

From Peggau.

THE *granular* baroſelenite, or *ſulphat of barytes*, is one of the rarer ſpecies of this genus of ponderous earth. That of *Peggau*, in *Stiria*, which is the ſubject of this eſſay, occurs of a beautiful milk-white colour, is maſſive, reſplendent, finely-grained, ſemi-indurated, and brittle. It bears a very ſtrong reſemblance to the white, fine-grained Carara-marble; to ſuch a degree, that, by its mere appearance, it might eaſily be miſtaken for it, were it not for its greater ſpecific gravity, which is 4,380, and by which it is readily diſtinguiſhed.

A.

a) It loſes nothing of its weight by ignition.

b) When pulverized, and boiled with a large quantity of water, it imparts to this laſt nothing obſervable by the ſight, taſte, or ſmell. Of all the re-agents, only the ſolution of ſilver in nitric acid rendered the water boiled with it in a ſlight degree opaleſcent.

c) In like manner, nothing of it was diſſolved by digeſtion with muriatic acid. The only exception from this is an unimportant trace of iron, which was detected by Pruſſian alkali.

B.

a) *Two hundred* grains of this foſſil, mixed with 500 grains of carbonated pot-aſh, were ſubjected, for two

hours,

hours, to a moderately ſtrong red-heat. The maſs, which only conglutinated, was then pulverized, boiled with water, and the remaining earth collected upon the filter.

b) The alkaline fluid contained ſome ſiliceous earth, beſides the *ſulphuric acid of the barytes.* To ſeparate that earth, the fluid was fully neutralized by muriatic acid, and evaporated to dryneſs. The *ſilex* remaining, after the reſolution of the ſaline maſs in water, weighed 18 grains upon ignition.

c) The barytic earth freed from the ſulphuric acid (*b*) was covered with water, and combined with muriatic acid. After ſome digeſtion, the whole was found diſſolved, except a remainder of *ſiliceous earth*, of two grains weight, when ignited. When this laſt had been ſeparated, I cauſed the filtered ſolution to cryſtallize, by the uſual management; and it afforded, to the end, only muriat of barytes, partly in rhomboidal, partly in oblong ſix-ſided tables.

d) All theſe cryſtals I diſſolved again in water, and dropped ſulphuric acid into the ſolution only as long as it produced any precipitate. The regenerated *ſulphat of barytes*, when collected, waſhed, and dried, weighed 185 grains; but, when heated to redneſs, no more than 180 grains.

The mixture of this foſſil, in *one hundred parts*, therefore, conſiſts of:

Pure ſulphat of barytes.	*d*)		90
Silex	*b*)	9	10
——	*c*)	1	
			100

Or, becauſe in the ignited ponderous ſpar, or ſulphat of barytes, the *earth* is to the acid very nearly in the proportion of 2 to 1, the above foſſil conſiſts of:

Barytes	60
Sulphuric acid (free from water)	30
Silex	10
	100

XXXVI.

XXXVI.

CHEMICAL EXAMINATION
OF THE
TESTACEOUS SULPHAT OF BARYTES,

From Freiberg[*].

IT was, undoubtedly, the powerful attraction which the barytic earth has for ſulphuric acid, exceeding even that of the pure fixed alkalis, that induced the deſerving *Scheele*, who firſt diſcovered it as a diſtinct earth, to think that an alkaline ſalt is incapable of reſolving the natural mixture of baroſelenite into its ſeparate principles. On this account, when attempting to expel its ſulphuric acid, he reſorted to the imperfect and tedious proceſs of repeatedly working the ſtone to a paſte, with honey or oil, of calcining that maſs by means of the muriatic or nitric acids, and, at laſt, of extracting ſuch a part of it as had been diſengaged from the ſulphuric.

Yet there are ſeveral inſtances where the unaſſiſted force of attraction of pure alkali has been too weak to ſeparate the component principles of mixed bodies; while, on the contrary, when they have been employed in the carbonated, or otherwiſe neutralized ſtate, the deſired object has been attained by this new increaſe of attractive force.

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[*] Chemiſch. Annal. 1796. I. B. S. 387. It is, properly, a variety of common *ponderous ſpar*. *Kirwan* calls it *Baroſelenite*. The *author*, with the reſt of the *Germans*, and ſome *French*, calls it *(ſchalig) teſtaceous*, from its form, pretty equally ſpreading in length and breadth, but, comparatively, of inconſiderable thickneſs. *Emmerling* has given a maſterly detailed deſcription of its figure and varieties. See his *Lehrbuch der Mineralogie*, Gieſſen 1793. Vol. I. page 557. ſeq.—Tranſl.

This is the very caſe with ponderous ſpar, and is founded on the method learnt of *Wiegleb*: which is, to decompoſe it in a ſhorter, cleanlier, and more complete manner, by igniting it with carbonat of pot-aſh. This method, as to the moſt eſſential part, has ſince been univerſally approved and adopted.

It ſeems, however, to be the common opinion, that this decompoſition obtains, in the *dry way* only, and that the ſeparation of ſulphuric acid from barytes abſolutely wants the ſupport of red-heat; as, to my knowledge, no one has yet attempted the *humid way*, to effect it.

A.

a) *A thouſand* grains of *common*, *white*, *thick*, *teſtaceous baroſelenite**, in the pureſt ſelected pieces from the mine *Kurprinz Frederick Auguſt*, near *Freiberg* (in Saxony), were triturated with water to the fineſt powder, and then boiled for one hour, in a ſilver pan, with twice their weight of carbonated pot-aſh, and five of water, ſtirring them occaſionally, and ſupplying the loſs of water as it evoporated; which being done, more water was added, and the whole filtered. The reſidue weighed 910 grains, after waſhing and exſiccation. Muriatic acid was affuſed upon it ſucceſſively, until all efferveſcence ceaſed. After gentle digeſtion,

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* Thick-teſtaceous (*Dickschalig*), when from ¼ to ½ an inch thick.—Tranſl.

geſtion, the muriatic acid was filtered off from the ſtill undecompoſed barytic ſulphat, which, upon waſhing and drying, weighed 426 grains.

b) With this remainder of ſulphated barytes, the ſame proceſs of coction with double its quantity of carbonated pot-aſh, and five times that of water, was repeated.—The edulcorated powder amounted to 387 grains; of which, after extraction of the ſoluble part of earth by muriatic acid, there remained 198 grains ſtill undecompounded.

c) Theſe 198 grains, treated in the ſame manner with alkali and water, gave then 183 grains. Of theſe, the muriatic acid left again 128 grains of undecompoſed ſulphat of barytes.

d) When theſe had been boiled with pot-aſh and water, in the manner mentioned before, there remained 122 grains; which muriatic acid diſſolved, excepting a remainder of 96 grains.

e) After a new ſubſequent decoction with twice the quantity of alkali and water, there remained 90 grains; of which, upon extraction performed with muriatic acid, there appeared a reſidue of 72 grains; which,

f) Upon repeating the boiling with carbonic pot-aſh, left 69 grains of powder, and, after extraction by muriatic acid, 61 grains.

g) As I thus obſerved that the ſucceſs of the decompoſition of ponderous ſpar decreaſes in the proportion of its diminiſhed quantity, I had recourſe to the *dry way* for the final analyſis of that reſidue. For this purpoſe I mixed it with three times its weight of mild alkali, or carbonated pot-aſh, calcining the mixture in a ſilver-veſſel during the ſpace of half an hour. After ſoftening the maſs, there remained 50 grains of edulcorated reſidue; which now totally diſſolved in muriatic acid, only five grains of unattacked *ſilex* excepted.

The alkaline lixivium, obtained from that ignited maſs, and ſomewhat reduced by evaporating, then afforded three grains of *ſiliceous earth.*

h) I then evaporated, together, all the muriatic ſolutions mentioned before, to the point of cryſtallization; and they yielded, at the firſt two ſhootings, the muriated barytes in a perfectly pure ſtate.

i) The remaining ſolution ſeemed to exhibit ſigns of the preſence of ſome iron. It was therefore ſaturated with cauſtic ammoniac, and filtered. There collected on the paper a browniſh earth, which, when highly dried, weighed 1½ grain. Yet, notwithſtanding this ſmall quantity, it was not mere oxyd of iron; for, when diſſolved in muriatic acid, and treated by Pruſſian alkali, the fluid remaining, after the ſeparation of the blue precipitate, yielded half a grain of *alumine*, by combination with ammoniac. The portion of iron, therefore, amounted only to one grain.

k) The remainder of the ſolution of muriated barytes, being thus freed from thoſe foreign ingredients, was decompoſed by means of mild ammoniac. I then re-diſſolved the precipitated earth in muriatic acid, and put it in a gentle temperature for farther cryſtallization. Pure muriat of barytes cryſtallized, as long as the ſolution contained one drachm of it; upon which I committed it to ſpontaneous exhalation in the open air. It cryſtallized entirely, without leaving any drop of liquor, to regular cryſtals; of which the firſt ſhooting ſtill conſiſted of ſome tables of muriated barytes, but the ſubſequent ones afforded needle-ſhaped cryſtals of muriated ſtrontian-earth.

l) Upon this, I carefully collected the cryſtallized muriat of ſtrontian, diſſolved it again in water, and re-produced it again in its former ſtate of *ſulphated ſtrontian-earth*, by dropping ſulphuric acid into the ſolution. The ſulphat, waſhed and dried, weighed 8½ grains.

m) The whole of the cryſtallized muriat of barytes, which was collected, amounted to 18 drachms.

n) Another portion of *a thouſand* grains of ſulphated barytes, ground to a moderately fine powder, and ſubjected to intenſe red-heat for half an hour in a porcelain-crucible, loſt no more than ſeven grains of their weight; which loſs may probably have conſiſted only of the *aqueous particles* driven out in the proceſs.

It reſults from theſe experiments, that the *white, teſtaceous ſulphat of barytes*, in pieces ſelected of the utmoſt purity, and from the mine mentioned above, reckoning with *a thouſand* parts, is compoſed of:

Sulphated barytes	975
——— *Strontian-earth*	8,5
Silex	8
Oxyd of iron	1
Alumine	0,5
Water	7
	1000

B.

B.

The reſult of this analyſis, therefore, demonſtrates, that the *humid way* is likewiſe applicable in the decompoſition of ponderous ſpar, by means of alternate boiling with a concentrated aqueous ſolution of carbonated pot-aſh, and ſubſequent ſolution in any ſuitable acid.

This management affords, eſpecially in operations performed with great quantities, a double advantage. The *firſt* is, the ſaving of crucibles, which would be otherwiſe deſtroyed; the *ſecond* is this, that the remaining alkali, which ought to be recovered after the ſeparation of the newly-formed neutral ſulphat, is not liable to be contaminated in this method.

When ponderous ſpar is ignited or fuſed with pot-aſh, that part of the alkali which is not neutralized, during the proceſs, by the ſulphuric acid of the foſſil, will attack not only the ſiliceous and argillaceous earth, which are uſually contained in the ponderous ſpar, but alſo that which enters into the ſubſtance of the crucible. It will alſo retain a great part of thoſe earths, in a diſſolved ſtate, in proportion as the alkali, during ignition, gives out its carbonic acid, and becomes more or leſs cauſtic. On the contrary, if the proceſs of boiling be employed, no tranſition takes place in the alkali, from the mild or carbonated, into the cauſtic or pure ſtate; hence alſo no contamination of it with ſilex and alumine will ariſe.

XXXVII.

XXXVII.

CHEMICAL EXAMINATION

OF THE

CROSS-STONE (Staurolite.)

THE chemical analyſis of that foſſil, which is found at *Andreasberg*, on the *Harz*, and has the name of *croſs-ſtone*, *croſs-cryſtal* (*ſtaurolithus*), and conſiſts of double cryſtals, concreted in the form of a croſs, has already been inſtituted by two eminent chemiſts, *Heyer* and *Weſtrumb*. Both have long ago publiſhed their analyſes. It might therefore be deemed needleſs to add mine, if the following reaſons did not excuſe it.

It is well known, that both theſe chemiſts have found *barytes*, beſides *ſilex* and *alumine*, among the conſtituent parts of that foſſil. To ſuppoſe the preſence of barytes, in this inſtance, *Weſtrumb* was ſatisfied with the obſervation, that, by combination with ſulphuric acid, this earth forms a precipitate of difficult ſolution in water. From the ſtate of chemical knowledge of the ſimple earths at that time, it was indeed allowable, to conſider ſuch a precipitate, directly and without trial, as ſulphated barytes.

But ſince we have become acquainted with ſtrontian-earth, which likewiſe combines with ſulphuric acid to a difficultly ſoluble precipitate, that phenomenon alone is not ſufficient to determine, whether a certain earth, met with in any proceſs, be the barytic.

Heyer, on the contrary, when examining the ſtaurolite, found this conſtituent part of it to cryſtallize both in the nitric and muriatic acids; from which he could, with greater confidence, ſuppoſe it to be of a barytic nature. But, as he has given no particular account of the figure of its cryſtals, eſpecially of thoſe formed with the muriatic acid, I thought that a freſh examination of this foſſil might be a means to aſcertain, whether the earth mentioned was really the barytic, or whether the ſtrontian.

a) *One hundred* grains of white cryſtals of the croſs-ſtone, carefully freed by diſtilled vinegar from all adhering calcareous earth, were finely pulverized, and ſubjected to a low red-heat for half an hour, with a double quantity of carbonated pot-aſh. The maſs, which was then eaſy of trituration, was lixiviated with water, and left 109 grains behind.

b) To this reſiduum was added the ſmall portion of earth, which was ſtill obtained from the alkaline lye, by ſaturating it with an acid, and evaporation. I then gently digeſted it with muriatic acid, with which it effervesced, and depoſited *ſiliceous earth*, in a fine, ſandy form, weighing 32 grains, after previous ſeparation by the filter, and ignition.

c) The muriatic ſolution, ſuper-ſaturated with cauſtic ammoniac, gave a tranſparent, paſte-like precipitate, which, upon edulcoration, drying, and ignition, weighed 33 grains. It conſiſted of alumine, but ſtill mixed ſilex. For this reaſon, I combined it with ſulphuric acid, and evaporated it to a moderately dry ſaline maſs, which, again diluted with water, depoſited *ſiliceous earth*, amounting to 17 grains, when heated to redneſs. The true quantity of aluminous earth, therefore, amounted to 16 grains.

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d) The remaining ſolution was evaporated to a ſmaller volume, and the earth, which it ſtill contained, was precipitated by means of carbonated pot-aſh. This earth weighed 23 grains, when waſhed and dried. But when re-diſſolved in muriatic acid, it ſhot, to the laſt drop, into tabular cryſtals of muriated barytes: proving, by this, to be *true barytic earth.*

e) Since, in conſequence of other experiments, thoſe 23 grains of carbonated barytes are equal to 18 grains of *pure barytes*; ſince, moreover, the ſtaurolite loſt 15 per cent of the whole, on ignition, and, as this loſs was probably mere water, the proportion of its conſtituent parts is as follows:

Silex	*b*)	32	49 grs.
	c)	17	
Barytes	*e*)		18
Alumine	*c*)		16
Water	*e*)		15
			98 grs.

XXXVIII.

SOME FARTHER RESEARCHES

CONCERNING

WITHERITE and STRONTIANITE.

FIRST SECTION.

A.

IT is needleſs to prove, that chemical analyſes give more accurate reſults, the greater the quantity is of the ſubſtance ſubjected to decompoſition. But, at the ſame time, it is not leſs evident, that the expence of the proceſs increaſes in the ſame proportion. The chemiſt, therefore, who, beſides time, trouble, and patience, frequently ſacrifices a conſiderable ſum to his love for the ſcience, ſhould not be cenſured for parſimony, if he can but ſeldom perform his analytical experiments with ounces and pounds, but muſt commonly reſtrain himſelf to ſmaller quantities.

The following reſearches on *witherite* may afford an inſtance of what juſt now has been ſaid.

a) *Twelve ounces* of *witherite* from *Anglezark*, (near *Chorley*, in Lancaſhire) coarſely powdered, were gradually diſſolved in *fifty ounces* of a mixture, compoſed of one part of muriatic acid and three of water. Except a few grains of ſand, no reſidue was left. The filtered ſolution, when ſet to cryſtallize, gradually afforded 14 ounces 5½ drachms of *muriated barytes*.

b) The mother-water, remaining from that ſolution, had acquired a greeniſh colour; and, as likewiſe the cryſtals which laſt formed, ſeemed to tend a little to the green, I deſiccated them in a high heat, waſhed them with alkohol, and added the waſhings to the remaining fluid; which I then treated with cauſtic ammoniac, added to exceſs of ſaturation. By this management, the ſolution was rendered ſky-blue, and, at the ſame time, turbid, by a ſlight portion of earth which then ſeparated. This laſt, collected, and dried in the air, weighed 2½ grains; had a yellowiſh-white colour, and was *aluminous earth, mixed with iron.*

c) On ſuper-ſaturating the filtered fluid with muriatic acid, the blue colour diſappeared. I then treated it with pruſſiat of pot-aſh of the utmoſt purity. This produced a brown-red, tender precipitate, which I carefully gathered, waſhed, and deſiccated. But this, beſides that it was of ſo ſmall a quantity, had ſo firmly adhered to the filtering paper, that it could not be accurately ſeparated from it. It was, therefore, together with the paper, ſubjected to lowred heat, and the aſhes were extracted by liquid carbonat of ammoniac, until the portions of this, ſucceſſively employed, ceaſed to be tinged blue. When upon this, the volatile-alkaline tincture had been evaporated, there remained in the evaporating pan a bright-green, carbonated *oxyd of copper*, weighing half a grain; which diſſolved in a few drops of dilute ſulphuric acid, and immediately precipitated, in the reguline ſtate, on a poliſhed piece of iron, upon which it was dropped.

d) The mother-water of the ſolution of the witherite (*b*), previouſly purified with cauſtic ammoniac and Pruſſian alkali, was next combined with mild alkali prepared from tartar; and the precipitate, that appeared of a dazzling white, being diſſolved in muriatic acid, was left to ſpontaneous exhalation. Thus the ſolution conſtantly afforded muriat of ſtrontian-earth, in ſmall hexahedral cryſtals; which, re-diſſolved in water, and precipitated by carbonat of ammoniac, yielded 98 grains of *carbonated ſtrontian-earth.*

Theſe 12 *ounces of witherite,* which are equal to 5760 grains, conſiſted, therefore, of:

Carbonated barytes	5659 grs.
——— *Strontian-earth*	98
Carbonated oxyd of copper	0,50
Alumine, contaminated with iron, and dried in the air	2,50
	5760 grs.

The foregoing analytical proceſs ſerves to confirm the exiſtence of a ſlight trace of copper in the Engliſh witherite, which has been already obſerved by *Weſtrumb*[*], as well as the preſence of ſtrontian-earth, both in the Engliſh and Siberian witherite, noticed by *Lowitz*[†].

B.

Hitherto, the only places where carbonated barytes is found native, are *Anglezark,* in England, and the *Schlangenberg,* in Siberia; for, the report of its occurrence in the metalliferous mountains of Saxony has not yet been confirmed. However, this foſſil has of late alſo been diſcovered in a third place, which is the pit *Steinbauer,* near *Neuberg,*

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[*] *Chemiſche Abhandlungen, von Weſtrumb,* Hanover, 1793, vol. I. page 266.

[†] *Chemiſche Annalen,* 1795. I. Band. Seite 110.

Neuberg, in Upper-Stiria. It is found there in a ſtratum of ſpatoſe iron-ſtone, partly maſſive, or in conſiderable lumps, and in part coarſely diſſeminated in brown iron-ochre.

One hundred grains of this *Stirian witherite* diſſolved completely, and with effervefcence, in dilute muriatic acid. The whole of that ſolution ſhot into muriat of barytes, in tabular cryſtals; the aqueous ſolution of which was precipitated in the ſtate of ſulphated barytes, by means of ſulphuric acid.

SECOND SECTION.

A.

THE attemps made to free *witherite* from its portion of carbonic acid, ſimply by ignition, and to bring it thus to the perfectly cauſtic ſtate, have hitherto miſcarried, owing to its vitrifying with the maſs of the clay-crucibles; and, on the other hand, its conſuming, and, as it were, diſſolving, thoſe made of charcoal. On this account, I reſolved to repeat the experiment with a veſſel made of platina.

A piece of witherite, weighing 200 grains, was put in a platina crucible, previouſly weighed, and this laſt, when introduced into a ſaggar (*caſſette*) made of clay, was conveyed into the middle chamber, or fire-place, of the porcelain-furnace; where the intenſity of heat is at 136 degrees of *Wedgwood's pyrometer*. When the veſſel had returned from the fire, I found the weight of its contents diminiſhed 23½ grains. The calcined witherite appeared as a dirty-browniſh, coarſe powder; which ſo firmly adhered to the bottom of the crucible, that it could not be detached without injuring the latter. I, therefore, tried whether I could ſoften the calcined witherite with water. But, although

though the water affuſed upon it became intenſely heated, the ſeparation of the ſtone proved ſo difficult, as to oblige me to aſſiſt it by a boiling heat. The calcined witherite left at the bottom of the platina crucible ſome floſculous impreſſions; and, in general, its internal poliſh ſuffered much, though the external remained unimpaired.

The loſs of weight, amounting to 11¾ *per cent*, indicated that the witherite had not loſt much above one half of its carbonic acid. It was owing to this, that it would not entirely diſſolve in boiling water, and that the reſidue ſtill conſiderably efferveſced with acids.

In the filtered aqueous and clear ſolution of the calcined witherite, which had been directly preſerved in a well-ſtopped bottle, I obſerved, after ſome days, that the barytic earth had cryſtallized in ſeveral ſmall groups, between which various inſulated cryſtals formed diſtinct octahedrons. In order to obtain a greater quantity of them, I reduced, by boiling, all the water impregnated with the ignited barytes to one fourth part; ſeparated by filtration the pellicle of carbonated barytes, which formed on the ſurface of the fluid during the proceſs; and transferred the liquor, while yet hot, into a glaſs provided with a ſtopper. Before the water had thoroughly cooled, ſimilar cryſtals were formed, which I found conſiderably increaſed on the following day. Thus I ſaw with pleaſure confirmed by my own experiments the fact, that calcined barytes is cryſtallizable in water; which property *Vauquelin* and *Pelletier* have of late, each in a different way, diſcovered at Paris.

B.

Since, therefore, according to this laſt experiment, the barytic earth agrees in this point with the ſtrontian, it fol-

lows,

lows, that this property of any calcined earth to cryſtallize in mere water can no longer be conſidered as an excluſive character of ſtrontian-earth. But from this we can by no means conclude, that both theſe earths are *identically* the ſame. Their eſſential difference, beſides the other diſcriminating properties already known, principally depends on the ſpecifically different degrees of affinity, or chemical attraction, ſhewn by each of them for the various acids. Of this, the following experiment furniſhes a proof.

I mixed an aqueous ſolution of acicularly cryſtallized muriated *ſtrontian-earth* with a ſolution of *acetated barytes*; evaporated the mixture to dryneſs; expoſed the obtained ſaline maſs to a ſtrong red-heat in a crucible; re-diſſolved that ignited reſidue in water; promoted the cryſtallization of the filtered ſolution by the uſual means, and obtained only *muriated barytes*, cryſtallized in quadrangular tables.

The muriatic acid, therefore, quitted the ſtrontian-earth, and combined with barytes, with which it had a ſtronger affinity.—By this new demonſtration of the eſſential difference of theſe two earths, deduced from the different degrees of their attractions for acids, it may be hoped, that chemiſts will no longer entertain any doubts concerning the exiſtence of the ſtrontian as a diſtinct earth.

C.

Before I conclude, I ſhall yet notice, in a few words, the relations of barytes to pruſſiat of pot-aſh. The precipitation, effected by this laſt, of barytic earth from thoſe acids with which it forms ſoluble middle ſalts, has ſeveral times occaſioned erroneous concluſions. It was upon this, that *Bergmann* and others have founded their hypotheſis, aſcribing a metallic nature to that earth, already refuted by more accurate examinations. With no better reaſon, has even lately one of the principal French chemiſts* reckoned the precipitation of barytes by Pruſſian alkali among the characters which diſtinguiſh it from ſtrontian earth.—However, this precipitation does not take place, except when the pruſſiated pot-aſh employed is not entirely free from the neutral ſulphat, which uſually contaminates it; for, if the pruſſiat is perfectly pure, it is as little capable of precipitating barytes as any other of the ſimple earths. On this account, whenever I prepare Pruſſian alkali, to be uſed in accurate chemical experiments, I always repeat the proceſſes of its purification, until the ſolution of nitrated barytes is no longer, even in the leaſt degree, rendered turbid by it.

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* Journal des Mines, N. xxi. Prairial, p. 45. ſeq.

XXXIX.

CHEMICAL EXAMINATION

OF THE

SULPHATED STRONTIANITE

from Penſylvania[*].

AFTER the ſtrontian-earth had been eſtabliſhed as a peculiar, chemically-ſimple earth, it was to be expected, that it might likewiſe occur combined with *ſulphuric acid*, inſtead of the *carbonic*, as is the *ſtrontianite* from Scotland. This conjecture was already in part verified; as it has been found, that moſt of the ponderous ſpars contain ſulphated ſtrontian-earth in their mixture, though in only a ſmall proportion, not amounting in the baroſelenites, hitherto examined with this view, to more than from one to two *per cent*.

But the preſent analyſis will fully prove the exiſtence of a perfect *natural ſulphat of ſtrontian-earth*, without any portion of barytic ingredient.

The foſſil, in which I diſcovered this combination, has been known but a few years. It was at firſt called, *blue, fibrous gypſum, from Frankstown*, in *Penſylvania*. The following are its diſtinctive characters.

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[*] Sulphat of ſtrontian-earth (*ſtrontites*) has alſo been diſcovered lately in the beach at *Auſt-paſſage*, near *Briſtol*, in Glouceſterſhire, in ſeveral veins. This foſſil has been analyſed by *William Clayfield*. See *Contributions to Phyſical and Medical Knowledge*, &c. collected by Dr. *Beddoes*.—Tranſl.

Its colour is a pale ſky-blue. It occurs in flat layers, or ſtrata, from ¼, ½, to ⅝ of an inch thick, included between two even ſides; which laſt partly appear to be real ſeams, or joints (*ſaalbänder*), and, partly, are mere ſeparating ſurfaces, formed by ſmall clefts of the rock, filled with clay. On theſe exterior ſides the foſſil has a dull appearance; but, internally, it is poſſeſſed of the ordinary luſtre. It is eaſily comminuted, and conſiſts throughout of coarſe, parallel, brittle fibres, which form needle-ſhaped fragments.

The ſpecific gravity of this foſſil I found to be 3,830. This conſiderable weight naturally ſuggeſted a doubt of its belonging to the ſpecies of gypſum. For this reaſon, it has been conſidered as a variety of ponderous ſpar, and placed in the mineralogical ſyſtem in the character of *fibrous ſulphat of barytes*, This, however, is not more its proper place, than that of gypſum, or ſulphat of lime.

A

a) *Hundred* grains of the foſſil, finely pulverized, were boiled in one pound of diſtilled water; whereby it loſt three grains. The water of the decoction was rendered turbid by mild alkalis, by oxalat of pot-aſh, by the nitrated ſolution of ſilver; but, moſt of all, by muriated barytes.

b) The powder, when again dried, was treated with muriatic acid; which, a trace of iron excepted, extracted nothing that was obſervable.

B.

a) I ignited *two hundred* grains of ſuch pieces of the foſſil as were pure, and free from the grey argillaceous matter, that croſſes it in thin fiſſures. It loſt by this about one grain in weight; and the blueiſh colour paſſed into the light iſabella-yellow. It was next triturated, then mixed with 500 grains of carbonated pot-aſh, and the mixture expoſed in a ſilver pot to a moderate red-heat, during the ſpace of three hours. The maſs became grey, ſtrongly coaleſced, and nearly entered into fuſion. Upon this, I pulverized it, boiled it with water, and collected the earth upon the filter.

b) The alkaline lixivium was ſuper-ſaturated with muriatic acid, evaporated to dryneſs, and the ſaline maſs ſoftened again with water, and neutralized with alkali. As by this treatment no ſeparation of earth was obſervable, I ſaturated again the lixivium to exceſs with muriatic acid, and combined it with muriated barytes. In this way I obtained 254 grains of *barytic ſulphat*; which, upon ignition, weighed 250 grains.

c) That earth, which remained after the decoction of the ſaline maſs that had been fuſed with the alkali (*a*), was combined with dilute muriatic acid, which readily attacked, and diſſolved it entirely, with effervescence. Cauſtic ammoniac, added to the colourleſs ſolution, clarified by filtering, threw down the ſmall portion of iron which it contained in ſcarcely perceptible browniſh flocculi. The ſolution being thus freed from iron, I precipitated its earthy portion by carbonated ammoniac, aſſiſted by heat.

d) The earth hereby obtained was very white, tender, of a moderate gravity, and weighed 164 grains in its dry ſtate. It was again diſſolved in muriatic acid, and the ſolution made to cryſtallize by gentle evaporation. It gradually, and entirely, ſhot into long needled cryſtals of ſix unequal ſurfaces; which middle, or earthy ſalt, proved, upon trial, to be mere *muriat of ſtrontian-earth*. A little of this ſalt, brought into contact with the wick of a burning candle, gave to the outer flame a highly beautiful carmine-red; and a ſolution of it in moderately ſtrong ſpirit of wine burned with the ſame colour, when cotton, or printing paper, dipped into it, was ſet on fire.

Hence it appears, from this analyſis, that the above foſſil, with the exception of its trifling portion of iron, conſiſts ſolely of *ſulphated ſtrontian-earth.*

C.

I repeated this analyſis in a ſhorter way: by boiling with alkaline lye, without previous ignition.

a) *One hundred* grains of the foſſil, ground to a moſt ſubtle powder, were mixed with a triple quantity of carbonated pot-aſh, covered with ſix ounces of water, made to boil, and kept in that ſtate during half an hour.

b) The lixivium, filtered off from the remaining earth, was ſaturated to exceſs with muriatic acid, in which ſtate it continued clear; and was then combined with ſucceſſive portions of muriated barytes, till no more precipitate enſued. The *ſulphat of barytes*, thus produced, weighed 126 grains after waſhing and drying, and 124 after ignition.

c) The earthy part of the foſſil, which had been diſengaged from the ſulphuric acid by boiling with alkali, and had in its ſtead taken up carbonic acid, weighed 82 grains. Muriatic acid diſſolved it entirely, and with rapidity, leaving only a few brown particles behind. The filtered ſolution was firſt treated with an over-proportion of cauſtic ammoniac, and, when no longer rendered turbid by it, was precipitated by mild, or carbonated pot-aſh.——It gave again its former weight of *carbonated ſtrontian-earth*; namely, 82 grains, when dried in the air. When heated to redneſs, it formed a moderately conglutinated maſs, and occupied only one half of its former volume; yet it did not loſe an entire grain in weight. After trituration, though previouſly ignited, it diſſolved rapidly, and with efferveſcence, in muriatic acid; and gave, by this combination, *muriated ſtrontian-earth*, in long, thin columns, of ſix unequal lateral ſurfaces.

Hence, the reſult of this decompoſition in the *humid way*, accompliſhed ſo completely, and with ſo much eaſe, moſt exactly correſponded with that of the preceding.

Now, ſince previous experiments have ſhewn, that 126 parts of *barytic ſulphat* contain 42 of *real ſulphuric acid*, or *without water*; and ſince 82 parts of carbonated ſtrontian-earth contain 58 of *pure ſtrontian-earth*, the proportion of the ingredients conſtituting the Penſylvanian, blue, fibrous, *ſulphated ſtrontianite* is accordingly:

Strontian-earth	58
Real *ſulphuric acid*	42
Oxyded iron, a ſlight trace	
	100

By theſe analytical experiments it is fully proved, that I was not miſtaken, when I ſuſpected this foſſil to be a ſulphat of ſtrontian-earth. In forming that conjecture, I was chiefly determined by its ſpecific gravity, which is conſiderably leſs than that of ponderous ſpar; and, likewiſe, by its fibrous texture: for, even the artificial combination of ſtrontian-earth with ſulphuric acid, effected by diſſolving that earth in this acid, cryſtallizes into needles, reſembling the fibres of the foſſil, though ſmaller and more delicate.

XL.

XL.

CHEMICAL EXAMINATION OF THE *WATER OF THE BOILING SPRING*,

at RYKUM, *in Iceland*[*].

CONSIDERING the ſlowneſs, with which the knowledge of the chemical properties of even the moſt common natural bodies uſually advances, it is not ſurprizing, that even thoſe of *ſiliceous earth* have ſo long remained but partially inveſtigated. This earth has always been conſidered as a ſubſtance, by itſelf, abſolutely inſoluble in water. It was, therefore, totally neglected in *hydrologico-chemical* inquiries, or reſearches into mineral waters, until *Bergmann* directed the attention of chemiſts to its ſolubility in ſimple water, and demonſtrated that it exiſts in a ſtate of ſolution in the Geyſer, and other boiling ſprings of Iceland.

But although, in this inſtance, this celebrated philoſopher juſtly conſiders the heat, which the water of thoſe ſprings poſſeſſes when it riſes into day, (and which even then is higher than that of ordinary boiling), as a means of promoting the ſolution, yet experience has ſhewn, that an actual ſolution of ſilex in water takes place, not only in ſprings, the natural temperature of which is much inferior to the ebullient heat of thoſe in Iceland, but alſo in ſeveral other mineral waters: and even that ſome common ſweet-water ſprings contain diſſolved ſiliceous earth.

Thus, when I was attentive to this point, whilſt analyſing the mineral waters of *Carlſbad*[*], I found that 1000 cubic inches of the main ſpring contain 25 grains of *ſilex*, actually diſſolved.

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[*] Read in the *Royal Academy of Sciences at Berlin*, Auguſt 28, 1794.

That this is not the greateſt quantity of ſiliceous earth ſoluble in water, and that, eſpecially, the hot ſprings in Iceland might poſſibly contain a much larger proportion of it, I was led to conjecture from the *ſiliceous tufas* which they depoſit in conſiderable quantities. At that time, however, a proof of this opinion, ſupported by chemical inveſtigation, was ſtill wanting. It gave me, therefore, the greateſt pleaſure, when I received a ſufficient quantity of water of one of the principal Icelandic ſprings, which enabled me to perform this inquiry, and to compare its reſult with that of the analyſis of Carlsbad water.

. . . . .

In modern times, *Uno von Troil*, and after him, *Banks* and *Solander*, have particularly deſerved well of the Natural Hiſtory of Iceland, ſo remarkable in ſeveral of its individual ſubjects, ſome of which are *unique* in their kind. The lateſt voyage to that iſland, undertaken for the purpoſes of Natural Hiſtory, is that of *Stanley*, in the year 1789. This learned traveller, (who has given in the papers of the Royal Society of *Edinburgh* a circumſtantial deſcription of the ſpring at the Geyſer), when collecting the natural products of that ſpot, had likewiſe providently brought back with him a number of bottles filled with the water of thoſe ebullient ſprings.—Two of theſe, that came to my hands, ſerved for the following analyſis.

The water contained in both bottles is from the ſpring at *Rykum*. From this ſpring, 24 Engliſh miles diſtant from *Hafnifiord*, the water ruſhed formerly out to the height of 60 or 70 feet. But ſince the orifice of the ſpring has been covered, for the greateſt part, by an overthrow of the rock, the ſtream of water, at preſent, ſpouts off ſideways, from 50 to 60 feet. The heat of this ſpring, even after the jet, is ſtill ſo intenſe, that Fahrenheit's thermometer riſes to 212°. Therefore, as it is beyond a doubt, that part of the heat is loſt during the ſpouting, and, conſequently, that the water muſt have been ſome degrees hotter in its ſubterraneous reſervoirs; Nature affords us here an inſtance, in the large way, of what Art performs in the ſmall, by Papin's digeſter: namely, that confined water, even while in its unelaſtic, denſe, liquid ſtate, is capable of acquiring a degree of heat, ſurpaſſing that of its boiling point.

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* See p. 274 of this work.

The water, in both bottles, was clear, bright, without ſediment, and without taſte. Yet, at the ſpring itſelf, it ſhewed ſome ſulphureous ingredient, according to *Stanley*. For, when employed freſh from the ſpring, it gave to the infuſion of tea prepared with it, as well as to the meat boiled in it, a nauſeous taſte; whereas, the water from the ſpring at the Geyſer, uſed in the ſame manner, gave no ſign of it. But as, in the water which I examined, I could not diſcover any ſulphur, either by the taſte, by the ſmell, or by re-agents, it remains undecided: whether this effect proceeded from a portion of highly volatile, ſulphurated, hydrogen gas, only obſervable at the ſpring itſelf, or whether, perhaps, the ſmell produced by putreſcent, organic ſubſtances has not been miſtaken for it; which laſt is not ſeldom the caſe, with various waters, ſuppoſed to be hepatic.

On employing other re-agents, it appeared, that this water from *Rykum* contains neither free carbonic acid, nor iron, nor lime, nor magneſia; and that *carbonated*, *muriated*, and *ſulphated ſoda*, are to be expected.

Guided by theſe previous indications of the conſtituent parts of this water, I performed its analyſis in the following manner.

[illegible] I evaporated

I evaporated *a hundred cubic inches* of it in a gentle ſand-heat. When this quantity had been reduced to a remainder of about ſix cubic inches, I found it coagulated to a pale-browniſh, ſtiff, ſomewhat turbid jelly. This evidently ſhewed, that this water had contained a conſiderable portion of diſſolved ſiliceous earth, which now appeared in its uſual gelatinous form. After the evaporation had been carried on to perfect dryneſs, the powder which was left weighed 25½ grains.

To ſeparate the *ſiliceous earth* from this reſidue, previouſly to the ſubſequent operations, I poured water upon it, and when ſoftened, I threw it upon the filter, waſhed the ſeparated earth, and expoſed it to a moderate temperature, to dry. It appeared in a delicate, looſe, pulverulent ſtate, and weighed nine grains. To diſcover whether it was pure, or mixed with any other ſoluble earth, I digeſted it with muriatic acid; but when this was again filtered off, it contained nothing extraneous, except a trace of *aluminous earth*, hardly worth noticing.

Hence, the ſalts ſtill held in ſolution, deducting the nine grains of ſilex, amounted to 16½ grains. Concentrated acetic acid was then dropped into the liquor to the over-ſaturation of the ſoda; and when the mixture had been evaporated to dryneſs, I ſeparated, by highly rectified alkohol, the acetite of ſoda thus produced, and found the weight of the reſidue, again deſiccated, to be 13½ grains. From this it followed, that the ingredient, *carbonat of ſoda*, reckoned in its dry ſtate, amounted to three grains; which are equal to eight grains of cryſtallized mild ſoda.

Thoſe 13½ grains, which yet remained, were liquefied in a little water, and the ſolution left to ſpontaneous evaporation. It gave cryſtals of *muriated* and *ſulphated* ſoda. To find the proportion of theſe two ſalts to each other, I re-diſſolved re-diſſolved the mixture in water, and decompoſed it: firſt by acetated barytes, and then by nitrated ſilver. Calculating afterwards the quantities of the precipitated ſulphat of barytes, and muriat of ſilver, upon the baſis of other comparative experiments, I found, that in thoſe 13½ grains were contained 8½ grains of *common ſalt*, and five grains of *Glauber's ſalt*, reckoned in its dry ſtate, or 12 grains, if cryſtallized.

According to this, the above 25½ grains of ſalt, afforded by 100 cubic inches of water from the boiling ſpring at Rykum, when deprived of their water of cryſtallization, or in the deſiccated ſtate, conſiſt of:

Carbonat of ſoda (natron) . . .	3 grs.
Sulphat of ſoda (Glauber's ſalt) . .	5
Muriat of ſoda (common ſalt) . .	8,50
Siliceous earth	9
	25,50

Shortly after the concluſion of the foregoing analyſis, I found in the *Annales de Chimie, Paris*, 1793, that a ſimilar examination had been made of the Icelandic hot ſprings, by Dr. *Black* of *Edinburgh*, together with a full detail of the method he purſued. In this inquiry, he likewiſe was ſupplied with the water by Mr. *Stanley*.

In order to compare the reſults of the analyſis of the ſpring-water at *Rykum*, made by Dr. *Black*, with mine, I reduced the conſtituent parts, enumerated by him, to the proportion of 100 cubic inches, equal to 29,000 grains of water. Hence, omitting unimportant fractions, they ſtand in the following proportion:

Carbonated free ſoda . . .	1,50 grains
Silex	10,80
Muriat of ſoda	8,40
Dry *ſulphat of ſoda* . . .	3,70
	24,40.

When the numerous, and partly unavoidable cauſes are conſidered, which occaſion ſmall differences in the proportion of the conſtituent parts diſcovered, theſe two analyſes may be conſidered, upon the whole, as reciprocally confirming each other. The quantity of *alumine*, which, being very trifling, I have not determined, ſhould, according to Dr. *Black's* analyſis, be eſtimated at $\frac{1}{7}$ of a grain in 100 cubic inches of water.

What in particular has attracted the attention of Dr. *Black* is the *ſiliceous earth* he diſcovered, and its ſolution in water. For this reaſon he ſays, that in the courſe of that inquiry he had detected in ſilex ſuch properties as have never before been ſuſpected in it, or never been accurately deſcribed. He here principally alludes to the fact, that ſiliceous earth diſſolved by fixed alkalis will not ſeparate from them, even when neutralized by alkalis, as long as a ſufficient quantity of water required to that effect is preſent*.

Dr. *Black* aſks; "How and by what means is the ſiliceous earth diſſolved in water?—Is the hot water, of its own accord, poſſeſſed of the power of diſſolving this

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* Without inculpating the ingenious Dr. *Black* for this little deficiency in his acquaintance with the experiments made by the German Chemiſts, I cannot avoid remarking, that I have, at an earlier period, known and deſcribed that property of ſiliceous earth. See my *Chemiſche Unterſuchung des Elaſtiſchen Steins aus Braſilien,* im. 6. B. der *Schrift. d. Berl. Geſellſchaft Naturforſch. Freunde.* 1785.

“ earth; or can this be effected only by the means of the “ intervening alkali?”—In anſwering theſe queſtions, he does not approve of *Bergmann's* opinion, that the ſolvent power of water, aſſiſted by heat, is alone ſufficient for this effect. He rather thinks, that the alkali is the efficient cauſe of this ſolution, and the heat merely a means of promoting it. In his opinion, a chemical combination of the ſilex with alkali is always preſent, when water exerts a diſſolving power on the earth, and this idea he ſupports by the example of the agency of hot aqueous vapours upon glaſs. The doubt, which might be raiſed againſt it, from the diſproportion of theſe two ſubſtances to each other in the Iceandic hot ſprings, he wiſhes to obviate by ſtating, that the ſilex had originally been united in them with a much larger portion of alkali; but that, ſubſequently to the ſolution of this compound in water, part of the alkali had again been neutralized by acids, or acid vapours, that combined with the fluid. But there is no neceſſity for this mode of explanation; as it is manifeſt by ſeveral facts, that ſiliceous earth alone, if under favourable circumſtances, is ſoluble in water, without the concomitant aid of alkaline ſalt.

Moreover, this opinion, that the ſilex exiſts in the above mentioned ſprings in a ſtate of chemical ſolution by ſoda, ſeems likewiſe to have led Dr. *Black* to preſuppoſe this alkali in thoſe waters in the *cauſtic* or *pure ſtate*, that is, *free from carbonic acid*; becauſe it is allowed on all hands, that, in this ſtate only, is it capble of effecting this ſolution. Yet, not to mention that no proof is given of this hyphotheſis, there occurs no inſtance in nature, upon which to eſtabliſh its probability. The very efferveſcence, that enſued on ſaturating with acetic acid the ſaline reſidue left by the evaporated water, would prove the contrary; unleſs, indeed, it be objected to this argument, that the alkali had attracted the carbonic acid, during the evaporation of the water.

XLI.

XLI.

CHEMICAL EXAMINATION

OF THE

SILICEOUS TUFA, (Kieſeltuff.)

From the Geyſer.

IN the ſame manner, as mineral waters impregnated with lime depoſit the *calcareous* tufa in various forms, do the hot ſprings in Iceland depoſit their *ſiliceous* ingredient in the form of tufa. It is likewiſe of this *ſiliceous* tufa that the wonderful pipe and baſon conſiſt, which the *Geyſer*, the largeſt of the ſprings in Iceland, has formed for itſelf. *Von Troil* found, in the year 1772, the circular orifice of that pipe, whoſe depth is unknown, and which the ignorant Icelander conſiders as the gate of hell, to be 19 feet in diameter. On the upper part, the aperture widens in the form of a large baſon of 60 feet in diameter, and whoſe exterior border is 9 feet higher than the pipe itſelf. From this pipe the water ſpouts out ſeveral times in the day, by guſhes, at unequal intervals of time, with powerful force, and ſometimes to the height of above 100 feet. What a grand ſight muſt it afford, to ſee a column of boiling water, 19 feet in diameter, ruſh up to ſuch a height! To form an idea of that column of water, let it be compared with the moſt celebrated artificial fountains, for example, that on the *Carlsberg* near *Caſſel* in *Heſſia*, which is only 14 inches in diameter, and hence is more than 16 times ſmaller than the Geyſer.

As the ſiliceous tufa produced by this ſpring is to be met with only in few collections; and as,—beſides the ſhort account given by *Bergmann*, in his treatiſe *De Productis Volcanicis*,—no other characteriſtic deſcription of it exiſts, I here inſert that, which *Karſten* has drawn from the ſpecimens in my poſſeſſion.

SILICEOUS TUFA.

"Its *colour* is partly *reddiſh-white*, and externally ſpeckled with *cochineal-red*; partly *greyiſh-white*, with yelloiſh-grey ſtripes.

"It occurs in *maſſive* lumps, and alſo *denticulated*, *coroded*, and moſt finely *botryoidal*.

"Its exterior ſurface *perfectly-dull*.

"But internally partly *dull*, in part highly *glittering*, and then of a *ſilky luſtre*; here and there a little *reſplendent*.

"Its fracture partly *compact*, and totally *flat conchoidal*, or *uneven*; partly *fibrous*.

"It breaks into indeterminate angular, not very ſharp fragments.

"It conſiſts, when conchoidal, of *finely grained* inſulated pieces; when of uneven fracture, it then is found in ſeparate *thin* and *curved teſtaceous* pieces; and its fibrous varieties preſent no detached pieces.

"It is alſo, more or leſs, *ſtrongly tranſparent on the edges*.

“ *Semi-indurated*; may be ſplit in pieces without any “ great difficulty; is very *brittle*, and of little *weight*.”

Note. The *fibrous* variety has always the luſtre of ſilk, and the fibres croſs each other in ſuch a manner, that its inſide has a *cellular* appearance.

For the following analyſis of the *ſiliceous tufa from Iceland*, I have choſen the *fibrous* variety, whoſe ſpecific gravity is = 1,807.

One hundred grains of it were finely triturated, and ignited for two hours, in a ſilver crucible, with four times its weight of mild pot-aſh. When the concreted maſs had cooled, I poured water upon it, ſaturated it to exceſs with muriatic acid, and filtered it after ſome digeſtion; upon which the *ſiliceous earth* remained behind in its uſual ſlimy form.

The acid fluid, being afterwards ſaturated with mild, or carbonated pot-aſh, was rendered turbid by it; and depoſited a ſlight looſe precipitate; which, collected, waſhed, and deſiccated, weighed 3 grains; but when re-diſſolved afreſh in muriatic acid, it ſtill left 1 grain of *ſilex*.

The ſolution ſtill contained 2 grains of diſſolved matter: namely, ½ grain of *oxyded iron*, and 1½ grain of *aluminous earth*. Theſe, likewiſe, were ſeparated.

Hence the ingredients, found in the above 100 grains of analyſed *fibrous ſiliceous tufa*, from the *Geyſer*, conſiſted of;

Silex	98
Alumine	1,50
Oxyd of iron	0,50
	100

XLII.

CHEMICAL EXAMINATION

OF THE

*ELASTIC QUARZ**,

(Sand-ſhiefer, flexible Sand-ſtone)

From Braſil.

THE ſingular elaſtic flexibility ſo ſeldom occurring in the mineral kingdom, in which this foſſil, in its form and appearance, reſembles novaculite (Turkey-hone), has attracted the attention of Naturaliſts, but at the ſame time has led many perſons to doubt its exiſtence as a natural ſubſtance, and to ſuſpect, that this may probably be a product of art. It comes from Braſil, near *Villa-rica*, the principal town of the province of *Minas Geraës*, which fact was, for a while, kept a ſecret. There it occurs in not very thick ſtrata, whoſe *hanging* and *ſhading ſides* are caſed over by a grey cruſt of ½ inch thick; and from thence it was brought to Portugal the firſt time, in the year 1780, by the *Marquis de Lavradio*, Viceroy at *Rio de Janeiro.* Among the ſpecimens I have ſeen, that of the Imperial Cabinet at Vienna, ſo remarkable for its precious foſſils, is by far the greateſt; it being 26 Vienna inches long, 16 inches broad, and 1 inch thick. It is, however, probable that this ſtone, together with its remarkable phyſical property mentioned before, was already known in the ſixteenth century; and that it is the ſame with that deſcribed by *Gaſſendi in Vitâ Peireſkii*[*] in the character of a *flexible wetſtone* (novaculite); as ſuggeſted by the authors of the *Göttingiſche Gelehrte Anzeigen*, when this ſtone has again been brought into notice[†].

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* Schriften der Berliner Geſellſchaft Naturforſchender Freunde. 6. B. 1785, pag. 322.—The miners indicate by theſe expreſſions the greater or leſs ſlope in the ſtrata, though chiefly with reference to *rake-veins*, not fully perpendicular. The hanging ſide is that towards the day, and is alſo called *hanger*; and the hading ſide, which likewiſe goes by the name *ledger*, is the under one next to the bed of the ſtratum. See *Williams's Natural Hiſtory of the Mineral Kingdom*, 8vo. Edinb. 1789. vol. I. page 269.—Tranſl.

A.

On inſpecting with a microſcope the homogeneous or integrant parts of which this elaſtic ſtone is aggregated, and which may be eaſily ſeparated by compreſſure or levigation, I found them all alike: that is, they were all flat, longiſh plates or ſcales, perfectly clear and pellucid. All their difference conſiſted in the variety of their outlines; ſome truncated more ſharply; others more obtuſely; others longer, but very thin; while others were broader and ſhorter; but moſt of them I perceived on one or both ſides notably ſinuated. I am inclined to think, that the elaſticity of this foſſil originates ſolely from the form of its aggregation. For, as may be diſtinctly ſeen at the firſt glance in the entire ſtone, all thoſe longiſh lamellæ are interwoven in *one ſingle* direction, and implicated in ſuch a manner, that each junction reſembles a vertebra, or hinge. With this idea alſo correſponds the particular kind of the flexibility of the ſtone, which is not tough or coriaceous. For, if the ſtone be held upright and ſhaken, it vibrates with ſome noiſe to and fro; but as ſoon as its agitation is diſcontinued, its parts conjoin again firmly by a force like a ſpring.

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[*] Libr. IV. ad annum 1630. pag. 254. Edit. 1706.

[†] Of the year 1784. Number 211.

B.

I now proceed to its chemical analyſis.

a) As, on triturating, I found the particles of the ſtone extremely hard, which was indeed previouſly aſcertained by its faculty of cutting glaſs with eaſe, and of ſtriking fire with ſteel, I endeavoured to facilitate its decompoſition by previous mechanical comminution.

To effect this, I ſubjected *one hundred* grains to red-heat, and quenched them in cold water; but I obſerved, that by this neither their weight nor their hardneſs had decreaſed. They were then reduced to an impalpable powder in an agate mortar, mixed with four parts of dried carbonated ſoda, and ignited under the muffle in a porcelain-ſaucer, during ſix hours, in a moderate degree of heat; by which the mixture only conglutinated, without actual fuſion. The ignited maſs was pulverized with water, ſuper-ſaturated with muriatic acid, digeſted and filtered. A quantity of very looſe *ſiliceous earth*, to the weight of 96½ grains, remained on the filter.

b) The ſeparated muriatic fluid was treated with Pruſſian alkali; and the blue precipitate, thence ariſing, ignited.

It weighed one grain; of which, however, only ½ grain can be reckoned as *oxyd of* iron, entering into the 100 grains of the decompoſed foſſil.

c) At laſt, by ſaturating the ſolution with carbonated potaſh, a tender earth was thrown down; which, after waſhing, drying, and ignition, weighed 2½ grains; and, examined by means of ſulphuric acid, was found to be *aluminous earth.*

Conſequently, *hundred* parts of *elaſtic quarz* from *Braſil* have yielded:

Silex	96,50
Alumine	2,50
Oxyd of iron . . .	0,50
	99,50

There are ſometimes very ſmall blackiſh grains, like points, mingled with this ſtone. As theſe probably are garnets, or cryſtals of horn-blende, it ſeems that the portion of iron and alumine diſcovered in the foſſil chiefly proceeds from them.

XLIII.

CHEMICAL EXAMINATION

OF THE

GLASS-STONE (Hyalite),

From Dauphiny[*].

As the term *Shörl* was formerly uſed in too vague a ſenſe; to remedy this uncertainty, it has been found neceſſary to confine its mineralogical ſignification within narrower limits. On this conſideration, the foſſil here treated of, which *Romé de l'Iſle* has firſt introduced into public notice, by the name, *Schörl tranſparent, lenticulaire*, but which has ſince become more known by that of *Violet-Schörl*, could no longer be ranked under that head. *Werner*, therefore, has claſſed it as a diſtinct ſpecies, and given it the name, *Thumerſtone*. But it alſo has got other names, ſuch as, *Glaſs-ſtone*, or *Haylite*, *Pſeudo-ſhörl*, *Glaſs-ſhörl*, *Oiſannite*.

It was, for the firſt time, diſcovered in *Dauphiny*, chiefly at *Bourg d'Oiſans* near *Allemont*; partly upon a blackiſh-grey horn-blende-ſlate, partly in the clefts of a greeniſh-grey gneiſs, already ſomewhat ſoftened by decay, where it is accompanied by quarz, amianth, and cryſtallized actinolite. Moſt of its cryſtals are upright, and their leading figure is very compreſſed rhomboidal parallelopipedons or flat rhomboidal tables, ſharply truncated, and of a fine ſtriated ſurface. The colour of the purer tranſlucid cryſtals is a faint amethyſtine-red, which in the leſs bright cryſtals changes to the white-grey.†

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[*] See Magazin für Die Naturkunde Helvetiens. I. B. 1787 pag. 180.

Glaſs-ſtone, or *hyalite*, is alſo found in the Pyrenees at *Barèges*, and other places; but not in ſuch clear and large cryſtals as that of Dauphiny.

The third place where this foſſil occurs is the mine *Niklas*, at *Thum*, near *Ehrenfriedersdorf* in Saxony; where it is rarely met with in a cryſtallized ſtate, but moſtly in ſeparate, maſſive, teſtaceous pieces.

Beſides theſe, I have likewiſe found it in a ſpecimen of native ſilver, from *Kongsberg*, preſerved in the inſtructive collection of Mr. *Siegfried* at Berlin.

a) Glaſs-ſtone, treated upon charcoal before the blowpipe, foams much as ſoon as it becomes red-hot, and readily melts into a black, ſhining, opake bead. This phenomenon, along with the great difference of its external characters, affords a ſufficient ground to ſeparate the *hyalite* from *ſhörls*, with which it has been confounded. The true *ſhörls*, indeed, likewiſe fuſe upon charcoal; however, *firſt*, their fuſion is not accompanied by a briſk effervescence, but rather by a languid ſwelling; *ſecondly*, a much ſtronger and more laſting heat is required, to make pure ſhörls run into a globule equally fuſed in all its parts; and, *thirdly*, moſt ſpecies of ſhörls, if not all, loſe their colour by the fire; whereas the cleareſt and leaſt coloured fragments of that foſſil yield a completely black vitreous bead. In this reſpect, hyalite agrees more with horn-blende [*].

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† Fuller deſcriptions of its external characters are found in the later mineralogical elementary books, among which deſcriptions, that given by *Eſtner* is the moſt complete. See his *Mineralogy*. II. B. I. Abth. S. 258.

b) To diſcover the conſtituent parts of hyalite, I choſe that from Dauphiny, firſt mentioned. *One hundred and ſixty* grains of the pureſt cryſtals, broken off from ſeveral *druſes* (regular cryſtalline groupes), were ignited for one hour in a porcelain-pot, at a degree of heat not intenſe enough to fuſe them. Their weight, colour, figure, and hardneſs, continued unimpaired. Only three grains were loſt during trituration.

c) Theſe 157 grains of the pulverized ſtone, mixed with three times their weight of exſiccated ſoda, were expoſed for three hours to a gentle red-heat, in a procelain pot. After cooling, they were found conglutinated into a blueiſh-grey, compact, hard, finely porous maſs, readily ſeparable from the ſides of the veſſel. When finely ground, covered with water, and ſuper-ſaturated with muriatic acid, the mixture acquired a gelatinous conſiſtence, and a dirty brown colour. On diluting it with more water, and digeſting it, oxygenated muriatic acid gas was extricated, and the brown colour diſappeared; the fluid, ſuperincumbent on the undiſſolved, white, ſlimy earth, being clear and of a gold-yellow. This earth, after decanting the liquor, was digeſted anew with muriatic acid; then ſeparated by filtration, waſhed, and ſtrongly ignited. It weighed 79 grains, and was *ſiliceous earth*.

d) To obtain firſt of all the metallic part of the ſolution, I gradually dropped Pruſſian alkali into it, as long as any

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[*] On the habitudes of this foſſil in porcelain-fire, ſee Eſſay I. No. 36.

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precipitation would enſue. The deep-blue precipitate, thus procured, weighed 61½ grains, upon waſhing and drying; but, when ſtrongly ignited, there remained only 28 grains, which conſiſted of *black oxyd of iron*, obeying the magnet. From theſe muſt be ſubtracted the portion of iron retained by the ſalt employed; and hence, (from the reſult of another eſſay, made on purpoſe with a portion of Pruſſian alkali of the ſame preparation) only 15 grains of that metal are left to be put in the account as a conſtituent part of the foſſil.

e) The amethyſtine red colour of the rough cryſtals, and the blueiſh colour of the maſs fuſed with ſoda, but ſtill more the vapours of oxygenated muriatic acid emitted during the ſolution, ſhewed that *mangaueſe*, as well as iron, was preſent in this inſtance. For this reaſon, I ignited thoſe 28 grains of oxyded iron (*d*), adding 10 drachms of nitre; and when this laſt had been for a while in red fuſion, I poured it off from the iron that lay at the bottom of the crucible upon a marble ſlab. When fixed again, the nitre appeared of an emerald-green. Thrown into water, it ſoon diſſolved, tinging the liquid of an amethyſtine-red; and, when this colour had vaniſhed, *manganeſe* fell down in light-brown, looſe flakes, weighing 1¼ grain. But, on being farther tried, it was found to be ſtill mixed with iron.

f) I next began to examine the diſſolved earths.—By the perfect and ready fuſion of hyalite alone, and without addition, I was induced to ſuſpect in it a conſiderable proportion of calcareous earth; but neither oxalic acid alone, nor oxalat of pot-aſh, produced any turbidneſs or precipitate. However, as the ſequel has ſhewn, lime was, nevertheleſs, preſent. This fact may ſerve as a caution, that even the very beſt re-agents ought not to be always truſted to with unlimited confidence.

Carbonated pot-aſh was now employed to precipitate the earth contained in the ſolution. It fell down, white, and of a looſe form; and weighed 91 grains after waſhing and deſiccation in a low heat. The fluid filtered off, together with the waſhings, were entirely evaporated, and the remaining dry ſaline maſs re-diſſolved with a little water. By this management 1½ grain of a granular earth was ſtill left, which I added to the preceding 91.

g) Upon theſe 92½ grains of earth I affuſed one ounce and a half of diſtilled vinegar, concentrated by freezing, leaving the whole ſtanding for 12 hours. A feeble, but laſting efferveſcence took place. The acetic ſolution being decanted, another freſh ounce of acetic acid was affuſed upon the ſediment; and, after 12 hours, it was expoſed to a moderate temperature. When, after 48 hours, the ſubtle earth, which gave the ſolution an opaline appearance, had ſubſided, I collected it upon the filter; waſhed, dried, and ignited it. It weighed then 41½ grains. At this time the acetic ſolution yielded a white precipitate, by uncombined as well as by neutralized oxalic acid. But, as from this alone no certain concluſion could be made as to the preſence of lime, I added to that fluid ſucceſſive portions of ſulphuric acid, till the white granular precipitate ceaſed to fall down. The mixture, a little evaporated and filtered, left ſulphat of lime behind, which, after ignition, weighed 38 grains.

h) The liquor, filtered off from this laſt, was combined with cauſtic ammoniac. *Aluminous earth* fell down, weighing 2½ grains when ignited. The remainder of the ſolution afforded ſtill ſome ſelenite, on evaporation to dryneſs; which, ignited, left two grains, and was added to the preceding 38 grains (*g*).

i) In order to decompoſe the ſelenite, I boiled it during a quarter of an hour with a ſolution of carbonated pot-aſh, in ſuch a proportion as made the alkali predominate. The earth left behind weighed 26½ grains, after waſhing and torrefaction; and proved, upon trial, to be a highly pure carbonat of lime. Therefore, ſince nine parts of crude calcareous earth afford by ignition five parts of burnt or quick-lime, the above-mentioned 26½ grains are equal to 14¾ grains of *calcareous earth*, freed from water and carbonic acid.

k) Thoſe 41½ grains of earth (*g*), together with the 2½ grains (*h*), which I took for *alumine*, were combined with three drachms of concentrated ſulphuric acid, and then diluted with ſome water. The mixture exhibited a pleaſing roſe-colour; but which, on inſpiſſating the fluid almoſt to dryneſs, paſſed into a light blue: ſhewing thus the preſence of a ſmall trace of *mangeneſe*. On being re-diſſolved in water, it yet depoſited ſome *ſiliceous earth*, weighing 3¼ grains, after ignition. By ſubtracting theſe from the foregoing 44 grains, that were held in ſolution by the ſulphuric acid here employed, the quantity of *aluminous earth* found in the foſſil is reduced to 40¾ grains.

l) To be aſſured that this ingredient is pure alumine, unaccompanied by magneſia, I heated the ſolution to the degree of boiling, and gradually ſaturated it with elutriated chalk, until it efferveſced no more, and no acid could be obſerved to predominate. After gentle boiling for half an hour, I filtered the fluid, reduced its quantity by evaporation, and ſeparated the ſelenite which yet appeared. However, no ſign of ſulphated magneſia could be perceived in the ſolution, either by the taſte or by re-agents.

Thus the decompoſed 157 grains of *hyalite*, from Dauphiny, have yielded:

Silex	*c*)	79	82,75
——	*k*)	3¾	
Alumine	*k*)		40,25
Lime	*i*)		14,75
Oxyd of iron, including that of *manganeſe*	*d*)		15
			152,75
Loſs			4,25
			157

Wherefore, an hundred parts contain:

Silex	52,7
Alumine	25,6
Lime	9,4
Oxyd of iron and *manganeſe*	9,6
	97,3

XLIV.

CHEMICAL EXAMINATION
OF
CHRYSOPRASE,
And its concomitant Green Earth *.

CHRYSOPRASE is a natural product, hitherto excluſively of Sileſia, chiefly found near the village *Koſemütz*, in the Principality of *Münſterberg*; where it occurs in the clefts and disjunctions of a ſoft ſerpentine rock, together with quarz, hornſtone, chalcedony, opal, aſbeſt, talc, *(magneſia)* and various other ſpecies of earths †.

Authors are not agreed in ſtating the conſtituent parts of chryſopraſe. Their opinions chiefly differ with reſpect to the principle that produces the green colour of this ſtone: ſome aſcribing it to iron, others to cobalt, and ſome again to copper.

FIRST SECTION.

Analyſis of Chryſopraſe.

a) Some ſelected, pure pieces of chryſopraſe were heated to redneſs, and quenched in water. Their colour was hereby changed to a blueiſh-grey; and, by a ſecond torrefaction and quenching, into a blueiſh-white. The ſtone loſt 1½ *per cent.* by the ignition, and became ſo ſoft, that it admitted of being eaſily ground to a very ſubtle powder.

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* See *Beob. u. Entd. a. d. Naturkunde.* 2 B. 2 St. Berlin. 1788. p. 17.

† A more circumſtantial account of the natural hiſtory and bed of chryſopraſe, and the ſtones that accompany it, is given in *Lehmann's Phyſisch-chemiſchen Schriften*—and *Gerhard's* Beyträgen zur Chemie, *and Geschichte des Mineralreichs*; as alſo in his *Grundriſs des Mineralſyſtems.*

Three hundred grains of this powder, mixed with twice their weight of dry carbonated ſoda, were ſubjected to a low red-heat for ſome hours, in a veſſel made of porcelain-clay. The maſs was then powdered while yet warm, and digeſted with water. The ſolution acquired a dirty browniſh colour, and left, upon filtration, a grey-yellow reſidue of 44 grains when edulcorated and dried. It paſſed colourleſs through the filter, and by ſaturation with muriatic acid, it yielded a copious precipitate; which, collected, waſhed, dried, and ignited, conſiſted of 268¼ grains of *ſiliceous earth.*

b) Upon the 44 grains of reſidue, that were ſeparated on diſſolving the ignited maſs in water (*a*), introduced into a retort, I poured *eight* times their weight of nitro-muriatic acid, and digeſted them together. This done, I abſtracted the greateſt part of the acid, and what had diſtilled over I returned upon the contents of the retort; digeſted it once more, and then filtered the whole. There remained on the paper a white, looſe *ſiliceous earth*, weighing 20¼ grains upon ignition.

c) To the filtered ſolution I added cauſtic ammoniac in exceſs. Its colour, which before was of a dilute green, turned blueiſh; and a little browniſh matter fell down in the form of ſlime. Upon this precipitate nitric acid was affuſed in a ſmall retort, and again diſtilled off from it. This affuſſion and abſtraction were repeated twice more; and, at laſt, the retort was ſtrongly heated to redneſs upon charcoal. The reſidue I then diſſolved in weakened nitric acid. A brown *oxyd of iron* remained, amounting to ¼ grain, which, diſſolved in muriatic acid, afforded, with Pruſſian alkali, a deep blue; and, with tincture of galls, an ink-black precipitate. Whence this portion of iron, as it is ſo ſmall, can have no ſhare in producing the green colour of chryſopraſe.

From the nitric ſolution, cleared from iron, carbonated ammoniac precipitated ½ grain of looſe *aluminous earth*, weighed in the dry ſtate; but for which, in the ignited ſtate, only ¼ grain can be reckoned.

No trace appeared of *magneſian earth*.

d) The ſolution, ſuper-ſatuated with cauſtic ammoniac (*c*), was tried for lime; and with this view combined with carbonated ſoda. The precipitate produced was carbonat of lime. Upon deſiccation, it weighed 4¼ grains, which denote 2½ grains of *calcareous earth*, in the ignited ſtate.

e) The fluid, from which this lime had been ſeparated, ſtill preſerved its blueiſh colour (*c*), and yielded no precipitate, either with acids or with alkalis. For this reaſon, it was diſtilled to dryneſs. There remained in the retort a yellowiſh ſaline maſs, which again made a green ſolution with water. When this ſolution had been combined with mild pot-aſh, it depoſited only a ſlight portion of a white-greeniſh earth; the remainder would not precipitate, notwithſtanding all my endeavours: therefore, I dropped into the mixture as much nitric acid as was neceſſary to re-diſſolve the precipitate, and treated it with pruſſiat of pot-aſh, until the whole was ſeparated. The collected, waſhed, and dried precipitate had a ſea-green colour, and weighed 17 grains.

f) In this precipitate, therefore, that conſtituent part of chryſopraſe was contained, on which its green colour depends.—What then is this conſtituent part? Certainly not *iron*; for this, by its nature, will never diſſolve in cauſtic ammoniac, nor ever produce with it a blue colour. Beſides, it would have been precipitated of a deep blue, by the Pruſſian alkali, with which it was tried (*c*); and, laſtly, the oxyd of iron, of which there exiſts only a very ſlight portion in the chryſopraſe, had already before been ſeparated (*c*). Neither can it be ſaid, that *copper* forms any part of that precipitate. This metal does indeed diſſolve of a blue colour, in ammoniac, as does the above-mentioned precipitate; but as this property does not excluſively belong to copper alone, no deciſive concluſion can be deduced merely from this circumſtance. Moreover, the bright aqua-marine colour of this precipitate, produced by means of pruſſiated pot-aſh, has abſolutely nothing in common with the red-brown colour, with which copper always preſents itſelf, when thrown down from any ſolvent by that precipitant.

But the moſt convincing proof of the total abſence of copper in this inſtance was afforded by the following experiment: I expoſed the 17 grains of the greeniſh precipitate (*e*) to red-heat, in a crucible, and ſubjected the black-brown reſidue, which weighed ſeven grains, to vigorous digeſtion in nitric acid. By this treatment, a ſlight quantity of iron, originating from the Pruſſian alkali employed for the precipitation, was depoſited; and all the remainder afforded a green ſolution with nitric acid. This I diſtributed into two phials; putting into the one a piece of poliſhed iron, and into the other a ſtick of zinc. But in neither of them, both in the cold or heated, could the leaſt indication of copper be obſerved.

g) After I was thus fully certain that no copper was preſent, I could not account for this conſtituent part of chryſopraſe, otherwiſe than by taking it for *oxyded nickel*.

This

This concluſion was corroborated by all the phenomena above-mentioned, which wholly reſembled thoſe of other experiments which I made, by way of trial, with an oxyd, prepared from the utmoſt pure reguline nickel.

Being accuſtomed to repeat thoſe experiments, which lead to new diſcoveries, in order to ſecure myſelf, by the agreement of the reſults, againſt accidental miſtakes, I ſubjected another quantity of chryſopraſe to analyſis.

The blue ſolution of oxyd of nickel in ammoniac, which I then obtained, I diſtilled to dryneſs from a retort; after which, I roaſted the reſidue with wax, in a gentle heat, and tried to reduce it to the reguline ſtate upon charcoal, by means of borax and fuſible phoſphoric ſalt. The reduction ſucceeded with either flux; but it required to be ſtrongly aſſiſted by the blow-pipe. While reducing with borax, the metal would not eaſily run into a button; but, with the phoſphoric ſalt, it proved ſomewhat more fuſible, and yielded a white-grey bead, that exhibited a ſhining polyhedral ſurface, and a finely grained fracture.

Theſe metallic buttons were too few to admit of a farther examination. For this reaſon, I endeavoured to procure more of them, which I effected by decompoſing the green earth of chryſopraſe, deſcribed in the following ſection; and the third ſection will ſhew, that thoſe ſeven grains of the precipitate obtained by Pruſſian alkali, and ignited (*f*), denote 2⅓ grains of metallic nickel; or three grains of pure *oxyd of nickel*, when heated to redneſs.

Whence the conſtituent parts, produced from the 300 grains of *chryſopraſe* decompoſed, are:

Silex	*a*)	268¼	288,50 grs.
——	*b*)	20¼	
Alumine	*c*)		0,25
Lime	*d*)		2,50
Oxyd of iron	*c*)		0,25
Oxyd of nickel	*g*)		3
			294,50
Loſs, which the chryſopraſe ſuffers by ignition, and chiefly conſiſts of particles of water	*a*)		5,50
			300

With this proportion of the conſtituent parts of chryſopraſe, the reſults of ſeveral of my experiments agree pretty well. Yet I readily admit, that, on repeating ſuch experiments, ſome ſmall differences may take place, eſpecially in the portions of iron and nickel, ſince the green colour of this foſſil ſo often varies. In like manner, I have ſometimes diſcovered more ſenſible indications of magneſian earth, though never amounting to more than ½ *per cent.*

SECOND SECTION.

Analyſis of the Green Earth of Chryſopraſe.

a) Among the varieties of the glittering, fattiſh, green earth, that ſometimes accompanies chryſopraſe, I ſelected that for the preſent enquiry, which by its uniform apple-green colour is diſtinguiſhed from the others, as the moſt pure and leaſt contaminated with heterogeneous matters. Upon *three hundred* grains of this, put in a retort, I poured four times their weight of an *aqua regia*, compoſed of three parts of muriatic, and one of nitric acid, and at firſt digeſted them for a while. The action of the acid upon the earth was attended with an extrication of yellowiſh vapours. That portion of the acid which paſſed over was poured back into the retort, with the addition of one part of freſh nitric acid; and, after a ſecond digeſtion, diſtilled off to moderate dryneſs. The remaining maſs, whoſe green colour was now changed into a yellow, was again digeſted with the acid that had been abſtracted, and next ſeparated by filtering from the indiſſolvable reſidue.

b) This reſidue, which reſiſted the attack of the digeſting acid, conſiſted of a very tender, looſe, dazzling-white, and glittering *ſiliceous earth*, that weighed 105 grains after deſiccation in a red-heat. I mingled and ignited it with 210 grains of carbonated pot-aſh; upon which I triturated the maſs with water, ſuper-ſaturated it with nitric acid, digeſted and filtered it. In the fluid that paſſed through the paper nothing could be found, except *one grain* of ſilex.

c) The ſolution, ſeparated from the ſilex (*a*), had a green colour. It was combined with carbonat of pot-aſh, and the precipitate produced was edulcorated and dried in the air. This precipitate had a pale green colour, like the crude earth, and weighed 280 grains. By way of previous examination, I diſſolved *one fifth part* of it in muriatic acid, and tried the ſolution, which again exhibited its original green colour, in the following manner:

α). *Ammoniac* threw down a white green precipitate, which, on adding more ammoniac, in part re-diſſolved, and produced a blue tincture.

β) By means of *pruſſiated pot-aſh*, a copious ſea-green precipitate, inclining to blue, fell down.

γ) *Tincture of nut-galls* produced a faint ink-colour.

δ) With *alkaline ſulphuret* there aroſe a blackiſh precipitate.

ε) In the remainder of that fifth part of the muriatic ſolution I immerſed a *poliſhed iron*, which became tarniſhed, of a grey colour; but no ſign of copper, either in a cold or a warm temperature, appeared.

d) The other four-fifth parts of the green precipitate (*c*), which now contained one half ounce of rough earth of chryſopraſe, cleared from ſilex, were diſſolved in nitric acid, and treated with an over-proportion of carbonated ammoniac, ſhaking it ſeveral times. The ſupernatant blue ſolution was decanted on the next day from the reſidue; and to this laſt freſh portions of ammoniac were repeatedly added, till it ceaſed to afford a blue tincture, that could be obſerved.

e) The reſidue, left after the extraction by ammoniac, was a looſe white-grey earth, weighing 85 grains when dried in the air. It was diſſolved by digeſtion in nitro-muriatic acid, and treated with cauſtic ammoniac, until nothing more fell down. The light-brown precipitate then obtained was heated to redneſs; after which it weighed 26 grains. Nitric acid was next affuſed upon it in a retort, and again abſtracted by diſtillation; and this abſtraction and digeſtion were repeated twice more. I then urged the fire of the coals ſo as to redden the retort, powdered the calcined reſidue, diſſolved it in dilute nitric acid, and threw it upon the filter. There remained a red *oxyd of iron*, which, dried and deflagrated with wax, was attracted by the magnet, and weighed eleven grains.

f) The 15 grains which yet remained in the ſolution after the ſeparation of theſe 11 grains of iron (*e*), were precipitated by mild ſoda, deſiccated in the air, and extracted in the cold by diſtilled vinegar. This attacked it with efferveſcence; but, when again filtered off, and treated with carbonated ſoda, it depoſited, without any efferveſcence, a looſe earth, which after ignition weighed three grains; and, being tried with ſulphuric acid, proved to be *magneſia*. The remaining earth, now reduced to 12 grains, when calculated the ignited ſtate, was *alumine*.

g) There ſtill remained that fluid (*e*), from which the iron, and the magneſian and aluminous earths were precipitated by cauſtic ammoniac. It was warmed, and combined with carbonat of ſoda, which precipitated 1½ grain of crude *calcareous earth*, for which, to avoid ſmall fractional parts, I put one grain of burnt *lime* in the account.

h) I now return to the blue extraction, prepared with carbonated ammoniac (*d*). I diſtilled it, together with the water employed for lixiviating the reſidue, from a retort, almoſt to dryneſs. The reſidue I ſoftened with water, and found, that, upon filtration, it left ſeven grains of a pulverulent iſabella-coloured earth; which, by ignition, loſt one half of its weight, yet continued unchanged in colour.—When previouſly diſſolved in nitric acid, it was thrown down of a white-yellow by alkalis, of a pale olive by pruſſiated pot-aſh, and of a light-brown by arſenical alkaline ſulphuret; but by the tincture of galls it would not at all precipitate. On this account I conſidered it as an impure *oxyd of nickel*.

i) As no ammoniac any longer predominated in the fluid which had been filtered off from the iſabella-coloured earth (*h*), it had again a bright graſs-green colour. I now endeavoured

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endeavoured to ſeparate the ſubſtance which it held in ſolution, by adding alkaline ſalts.—Yet I could not completely ſucceed; and, notwithſtanding that I watched the moſt exact point of ſaturation, this middle (or earthy) ſaline liquor ſtill retained part of that ſubſtance in a diſſolved ſtate. The greateſt portion of the precipitate I firſt obtained by means of mild ammoniac; and when this had been ſeparated, mild pot-aſh threw down another portion. The precipitate, collected, waſhed, and dried in the air, had a pale, whitiſh-green colour, and weighed 50 grains.

k) *Thirty* grains of this precipitate were ignited for ½ an hour; whereby its whitiſh green was altered to a grey-green: and it loſt half of its weight. Thoſe 50 grains, therefore, muſt be eſtimated at 25 grains of ignited *oxyd of nickel.* In this inſtance I did not perceive that ſort of excreſcence which uſually takes place when oxyds of nickel, procured from ores of that metal, are expoſed to fire; perhaps, becauſe no portion of arſenic, by the eſcape of which thoſe delicate ramifications are probably produced, was here preſent.

l) Since neither acids nor alkalis would precipitate any thing from the remainder of the fluid above mentioned *(i)*, it now only remained to apply pruſſiat of pot-aſh. This ſtill precipitated a conſiderable quantity of a pale ſea-green earth; which, upon waſhing and ignition, became granular, aſſumed a brown colour, and weighed 21 grains. This quantity, calculated after the manner to be explained in the third ſection, indicates 9 grains of ignited, pure *oxyd of nickel.*

Therefore, the conſtituent parts contained in *half an ounce* of that variety of the *green-earth of chryſopraſe*, which had been employed for this inveſtigation, are the following:

Silex (ſince 105 grains were obtained from 300 grains of that earth)	*b*)		84 grains
Alumine	*f*)		12
Magneſia	*f*)		3
Lime	*g*)		1
Oxyd of iron	*e*)		11
Oxyd of nickel	*h*)	3½	37,50
——	*k*)	25	
——	*l*)	9	
			148,50
Loſs, very nearly approaching that which the rough earth of chryſopraſe ſuffers by red-heat			91,50
			240

THIRD SECTION.

Cloſer Examination of the Portion of Nickel contained in Chryſopraſe, and its concomitant Green-earth.

IN order to examine more accurately the whitiſh-green metallic oxyd that enters into chryſopraſe, as well as its concomitant green-earth, I procured another quantity of it, by repeated decompoſitions of thoſe two ſubſtances, performed in the manner before deſcribed. This I ſubjected to the following experiments.

a) Treated with *ammoniac*, it ſoon diſſolved, and yielded a pure blue tincture, though leſs ſaturated than that which is af-

afforded by the ſolution of copper in ammoniac, made with the ſame proportion of theſe reſpective ingredients. If nitric acid be affuſed in a quantity a little beyond what is neceſſary to ſaturate the ammoniac, the ſolution appears of a light graſs green.

b) It entirely diſſolved, and with effervescence, in *ſulphuric acid.* It likewiſe gave with this a green ſolution; from which

α) *Carbonated pot-aſh* precipitated that oxyd of a whitiſh-green.

β) *Pruſſian alkali* of the ſame, but ſomewhat darker colour.

γ) *Tincture of galls* produced no change nor turbidneſs in the ſolution.

δ) *Arſeniated alkaline ſulphuret* threw down a great quantity of a black-brown precipitate; but of which

ε) Neither on *poliſhed iron*, nor on *zinc*, any thing of a metallic nature would depoſit; the ſolution producing only ſome weak, grey ſpots on theſe metals.

ζ) By expoſure to open air, this ſolution ſhot into clear, emerald-green, rhomboidal cryſtals of *ſulphated nickel*, which, by roaſting, crumbled into a white-greeniſh powder.

c) The green oxyd of nickel, tried upon charcoal, with a blow pipe, ſhewed the following appearances:—

α) Ignited by itſelf, it became *violet*; but ſhewed no diſpoſition to fuſe.

β) With *borax*, aſſiſted by a continued ſtream of air from the blow-pipe, it fuſed, and was partially reduced to a white-grey metallic maſs; but which would not run into one ſingle button.

γ) *Phoſphated alkali* likewiſe reduced it to the reguline ſtate, at the ſame time that it more readily united into one bead. The glaſs globule exhibited, during the action of heat, a garnet-red, but, after refrigeration, a hyacinthine colour.

d) I now attempted its reduction in the *crucible*. With this deſign, I introduced the 15 grains of metallic oxyd, remaining after ignition from thoſe 30 grains mentioned (2 Sect. *k*), into a crucible, previouſly mixed with the ſame quantity of reſin, and three times that of calcined borax, and covered the whole with common ſalt. The veſſel was then conveyed to the melting-furnace, and the fire managed in about the ſame manner as on aſſaying copper. After cooling, the inſide of the crucible was found lined with a thin glazing, on ſome places of the upper part, of a green, but on the lower one, of a bright hyacinthine colour. The maſs itſelf fuſed well; and, on breaking the veſſel, there was found, under the colourleſs ſaline cover, a tranſparent light-brown glaſs, and, between this, a metallic button. This, however, being refractory, had not run into a compact maſs, but was only conglutinated, conſiſting of ſeparate, ſmall, looſely-coherent globules.

This metal had a perfect metallic luſtre, and a grey colour, verging to the red When freed by elutriation from the adhering ſcoria, it weighed 9¼ grains. But as here and there ſome minute grains were ſticking to the fragments of the crucible, not eaſily ſeparable, I may properly eſtimate them at ¼ grain; wherefore the weight of the *metallic nickel* is determined at 10 grains.

α) The *magnet* has attracted theſe metallic grains with ſuch rapidity, that, on its approach, the whole quantity adhered to it in an inſtant; and not one ſingle globule remained behind.

β) One grain of them by weight afforded, with *ſulphuric acid*, aſſiſted by heat, a graſs-green ſolution; from which

γ) *Ammoniac* again precipitated the metallic part, of a bright whitiſh-green; but, on being affuſed in greater quantity, it ſoon re-diſſolved it clearly, and of a ſky-blue colour.

δ) *Five* grains of this reduced nickel, diſſolved in *nitric acid*, and thrown down by *Pruſſian alkali*, then edulcorated and dried, gave a ſea-green precipitate; which, expoſed to red-heat, left 15 grains of a granular reſidue, wholly attractible by the magnet.

ε) Thoſe metallic grains urged by the flame upon charcoal, before the blow-pipe, exhibited no diſpoſition to melt, or fuſe, but turned to a greeniſh oxyd.

ζ) When fuſed with *borax*, they likewiſe would not readily enter into fuſion. The glaſs of borax turned aſh-grey and opake; and the metal remained in it in a divided ſtate.

η) But with fuſible *phoſphoric ſalt* they melted pretty ſoon into one ſingle bead, of a polyhedral ſurface. The glaſs globule, which, during the action of heat, was of a deep garnet-red, became tranſparent after cooling, and aſſumed a fine hyacinth colour.

e)Notwithſtanding that all theſe facts, taken together, ſufficiently demonſtrate that the conſtituent part of chryſopraſe, from which its peculiar green colour ariſes, is a *true oxyd of nickel*; yet I have, for the ſake of ſuperabundant evidence, made other experiments with an oxyd of nickel, which I prepared by the following method.

A portion of *ore of nickel*, from the pit *König David*, on the *Sauberg*, at *Annaberg*, was coarſely pounded, the pureſt pieces ſelected, converted into a groſs powder, and roaſted in ſhallow pots, as long as any arſenical vapour exhaled. The powdered ore acquired, by this, a dirty green colour, and vegetated, in part, into ramified figures. This oxyd of nickel I reduced with black flux, and obtained a yellowiſh-white, brittle, metallic button, of eaſy fuſion. This, being once more calcined, was digeſted in a retort, with an equal quantity of ſtrong ſulphuric acid; after which the acid was again diſtilled over to dryneſs, and the reſidue re-diſſolved in water, and filtered. At the beginning, the ſolution depoſited ſmall cryſtals of arſenic; and when theſe had been removed, the ſulphated nickel ſhot into beautiful, deep-green, rhomboidal cryſtals. This vitriol of nickel I again diſſolved in water, and precipitated it by means of carbonated pot-aſh. Upon the oxyd of nickel thus obtained, when waſhed, dried, and pulverized, ammoniac was affuſed. This laſt ſoon extracted a fine blue tincture, which, filtered off from the reſidue, was ſaturated with nitric acid; and, by means of mild pot-aſh, all the whitiſh-green earth which it would yield was precipitated from it.

With this oxyd of nickel, extracted in this way from its ore, I have inſtituted various experiments, for the ſake of trial; which, to avoid prolixity, I ſhall not particularly enumerate. I will, therefore, only ſtate, that this oxyd, as to the eſſential phenomena, has perfectly agreed with that extracted from chryſopraſe.

f) Thoſe who deſire information reſpecting the habitudes of nickel in general, I refer to the valuable treatiſe of *Bergmann* * on that metal; where he relates his experiments, made with unwearied patience, for the purpoſe of extracting the regulus of nickel, in a ſtate of purity, from its ores, in which it is conſtantly accompanied by foreign metallic ſubſtances. The difficulties which take place in thoſe proceſſes, I have found confirmed by my own experiments: but I think the beſt method of obtaining the reguline part of nickel is that deſcribed above; namely, by means of ammoniac: yet the product becomes ſomewhat expenſive.

In the chryſopraſe, on the contrary, the oxyd of nickel is not mixed with other metallic matters, a very ſlight portion of iron excepted; and ſince the proceſs which I have there given likewiſe ſerves to ſeparate this inconſiderable ferruginous ingredient, we may ſafely conſider the *metallic nickel*, produced from chryſopraſe, or its accompanying green earth, to exiſt in the ſtate of the *utmoſt poſſible purity*.

g) To this aſſertion, however, it may, perhaps, be objected, that the nickel obtained in that way ſtill obeys the magnet, and, therefore, yet contains ſome iron. But has it as yet been unqueſtionably proved, that iron alone is ſubjected to the law of magnetic attraction?—Have the arguments which various philoſophers have brought forward

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* *Torb. Bergmann* Opuſc. Phys. et Chim. vol. II. page 231. *De Niccolo*.

againſt this ſuppoſition, been completely refuted?—When the chemiſt no longer finds any trace of iron in pure cobalt, or in pure nickel, and, nevertheleſs, obſerves the magnet to act upon it—can his doubt, whether the attractive force of the magnet be confined only to iron, as has been hitherto believed, be fairly rejected without any farther inveſtigation?

b) I muſt yet mention ſome *experiments relative to vitrification*, for which I have uſed the rough chryſopraſe, as well as the oxyd of nickel extracted from it, in combination with various other vitrifying media.

α) *Rough chryſopraſe*, finely powdered and
elutriated, ... 1 part,
Carbonated pot-aſh, ... 2 parts,

mixed and fuſed in a crucible, afforded a violet-blue glaſs, which deliqueſced in the air to a browniſh fluid.

β) *Rough chryſopraſe* . . . 5 parts,
Carbonated pot-aſh . . . 4 parts,

gave, after a fuſion continued for two hours, a beautiful hard glaſs, of a violet-blue.

γ) *Rough chryſopraſe* . . . } equal parts
Dry *carbonated ſoda* . . . } of each

yielded a tourmaline-brown glaſs, tranſlucid only in thin ſplinters. Its ſurface had ſome delicate veins of reticular delineations; produced by extremely ſmall grains of reduced nickel, lying cloſe to each other in a linear range.

This reduction, which takes place without the addition of any combuſtible matter, is remarkable. *Lehmann* has before mentioned a bead of reduced nickel, obtained from chryſopraſe by reducing fluxes; but he miſtook its nature, erroneouſly conſidering it as iron.

δ) *Rough chryſopraſe*, and . . . . .
Calcined borax, in equal quantities,

gave a brown tranſparent glaſs, reſembling rock-cryſtal of that colour. *(Rauch-topas).*

ε)		
Prepared *ſiliceous earth* . .	80	grains,
Carbonated pot-aſh	60	
Oxyd of nickel, from chryſopraſe	3	

yielded a clear, violet-blue glaſs.

ζ)		
Prepared *ſiliceous earth* . .	80	grains,
Carbonated pot-aſh . . .	60	
Oxyd of nickel, from the ore of that metal of *Annaberg*, obtained by the proceſs mentioned at *(e)* . . .	3	

By this experiment I obtained a glaſs of a violet-blue colour, perfectly reſembling the laſt.

η)	
Prepared *ſiliceous earth*,	
Burnt *borax*; of each . . .	60 grains of each
Oxyd of nickel from *chryſopraſe*	3

produced a clear, light-brown glaſs.

θ)	
Prepared *ſiliceous earth*	
Vitrified *phoſphoric acid*, prepared from bones,	60 grains of each
Oxyd of nickel from *chryſopraſe*	3 grains,

have afforded a honey-yellow glaſs; but which did not become entirely clear.

i) Of the various inferences that may be drawn from the preceding facts, I will ſelect only a few.

Lehmann, to my knowledge, was the firſt, who obſerved that chryſopraſe affords a *blue glaſs* by fuſion with carbonat of pot-aſh. This obſervation is confirmed by the experiments of *Achard*, made on the ſubject of the fuſibility of various ſubſtances. The foregoing experiment (ι) ſhews, that this blue colour ſolely depends on the portion of nickel contained in chryſopraſe; and it is proved, by the experiment (ζ), that the oxyd of nickel, if freed, as much as is practicable, from extraneous admixtures, poſſeſſes the property of tinging glaſs-frits, mixed with mild pot-aſh, of a *blue* colour, on their vitrification. But what can be the reaſon, that this blue colour is not produced by means of mild ſoda employed in the ſame manner? To what cauſe is that difference to be aſcribed?

The ſame experiments alſo prove that *Le Sage* * was in the wrong, when he aſſerted that the metallic ingredient in chryſopraſe is cobalt. Beſides cobalt, we now know ſeveral metallic ſubſtances capable of producing a blue glaſs, under certain conditions, with which the chemiſt ſhould be thoroughly acquainted, before he infers from this the nature of any metallic ſubſtance. Thus, *cobalt* covers all fluxes, (enamels, glaſs-paſtes) blue; while *oxyd of wolfram* (tungſten) imparts a blue colour to ſuch frits only as are mixed with phoſphoric ſalts, leaving, on the contrary, thoſe colourleſs that are combined with borax. In like manner, the *oxyd of nickel* tinges blue the frits prepared with carbonat of pot-aſh; but brown, thoſe into which carbonat of ſoda, or borax, enters; and, laſtly, it produces a *honey-yellow* in ſuch as are mixed with a neutral phoſphat.

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* See *Analyſe Chimique et Concordance des Trois Règnes*, par Mr. *Sage*, tom. II. Paris, 1786, page 73.

Since, therefore, chryſopraſe does not afford a blue, but a *brown* glaſs, when melted with borax; this fact, together with the knowledge that no trace of any green ſympathetic ink is diſcovered in its muriatic ſolution, is alone a ſufficient evidence of the abſence of any portion of cobalt from that foſſil. *Le Sage* tells us, indeed, he has produced a blue glaſs from chryſopraſe and borax; but again this aſſertion of his does not correſpond with experience.

XLV.

CHEMICAL EXAMINATION
OF THE
NOBLE OPAL,

From Cscherwenitza, in Upper-Hungary.

IF the *Noble Opal*, effulgent with variegated colours (*chatoyant*) be contraſted with the colourleſs *rock-cryſtal* and the dull, dark coloured *flint*, it would hardly be poſſible, were it not for the conviction afforded by chemical experience, to be perſuaded that the chief conſtituent part of thoſe three ſpecies of ſtones, ſo diſſimilar in their external appearance, is the ſame ſimple, pure, ſiliceous earth, or, at leaſt, only in exceedingly ſmall proportions, mingled with foreign ingredients; and that it is only the difference in the ſtate of aggregation which modifies the one to opal, the other to rock-cryſtal, and the third to flint.

But that the *noble opal** really belongs to the pureſt ſorts of ſilex, is demonſtrated by the following analyſis.

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* *Eſtner* has publiſhed in his *Mineralogy*, vol. II. page 402 ſeq. an ample deſcription of this beautiful ſtone; taken principally from the valuable opals in the Imperial Cabinet at Vienna, ſo diſtinguiſhed by their beauty and magnitude; and, beſides, from thoſe in the collection of opals of Abbé *Neumann*, Director of the Imperial Cabinet of Medals, which, perhaps, is the moſt complete in its kind. Of the accurate agreement of thoſe deſcriptions with the originals, I had the pleaſure of convincing myſelf by my own inſpection, at Vienna.

A.

A piece of rough, or unwrought noble opal, weighing 76½ grains, was expoſed to fire, in a well-covered porcelain-veſſel. It crackled at the very firſt degree of heating. When the noiſe cauſed by this had ceaſed, it was kept in ignition for half an hour longer. After cooling, it was found burſt into ſmall ſlaty ſplinters, of a pure milk-white, and a ſurface partly glittering, partly of an enamel-luſtre. The yellowiſh ferruginous covering, which is perceivable even in the rough ſtone, and penetrates its extremely minutes fiſſures, was changed, by the ignition, to a *high-yellow-red*, and, in part, *irideſcent*, or exhibiting changes of rainbow colours. It experienced a loſs of weight of 7½ grains, or about 10 per cent.

B.

a) *Hundred grains* of rough, noble opal, finely-pulverized in the flint mortar with water, were mixed, after exſiccation, with 200 grains of dry carbonated ſoda, and ſubjected to moderate red-heat for two hours, in a ſilver-crucible.

The maſs, which but looſely coaleſced, was then triturated, ſoftened with water, ſuper-ſaturated with muriatic acid, and briſkly digeſted. The fluid formed a gelatinous coagulum as it cooled. When diluted with more water, and again digeſted, it was filtered, and the *ſiliceous earth* remaining on the paper thoroughly lixiviated, and ignited, after previous drying. It then weighed 90 grains.

c) The muriatic liquor was reduced to a ſmall bulk by evaporation, and treated with cauſtic ammoniac, added in ex-

exceſs. But only a very ſmall quantity of browniſh flocculi ſeparated, conſiſting merely of iron, and amounting to $\frac{1}{10}$ of a grain, when collected and ignited.

But, ſince the very pure white colour of the ignited opal evidently proved, that this ſlight portion of iron does not eſſentially belong to its mixture; and ſince, beſides, not the leaſt perceptible trace of alumine appeared, I can only reckon as real conſtituent parts, in the opal here examined, the following:

Silex	90
Water	10
	100

XLVI.

XLVI.

CHEMICAL EXAMINATION OF THE *SAXON HYDROPHANES*[*].

AMONG thoſe varieties of opal, which are known by the names, *hydrophanes*, *changeable opal*, *oculus mundi*, and poſſeſs the remarkable property of becoming tranſparent in water or other fluids, thoſe from *Saxony* are, beſides, particularly diſtinguiſhed by the beautiful opaleſcent play or change of colours, which they exhibit in that ſituation, of which ſome exhibit ſenſible indications, even in their natural dry ſtate.

Yet, although hydrophanes has been analyſed by various perſons, the proportions of its conſtituent parts are ſtated very differently.—From this diſagreement, *Wiegleb* was induced to inſtitute a new examination of this ſtone, which made it appear, that the argillaceous ingredient, to which that peculiar phyſical property of hydrophanes has been erroneouſly attributed, is a much ſmaller conſtituent part than has been aſſerted by various authors.

This inveſtigation, made by *Wiegleb*, does not thoroughly agree with the reſult of that which I performed with various hydrophanes, kindly given me by Baron *Racknitz*, of *Dreſden*, and found at *Selitz*, near *Hubertsburg*. This learned connoiſſeur and reſpectable promoter of mineralogical ſcience likewiſe confirms the circumſtance related by *Wiegleb*, that hydrophanes, while in the mine, is ſoft; and, in this ſtate, ſuſceptible of receiving impreſſions from hard bodies.

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[*] *Chemiſche Annalen*, 1790, part I. page 61. *Chemiſche Annalen*, 1789, part I. page 402.

a) *One hundred* grains of this Saxon hydrophanes were coarſely divided or bruiſed, and ignited upon red-hot coals, in a ſmall glaſs retort. At the end of this proceſs there appeared, in the receiver, an empyreumatic water, covered with a thin greaſy pellicle. The loſs of weight ariſing from this was $5\frac{1}{4}$ grains.

b) The ignited hydrophanes was then triturated to a ſubtle powder, mixed with twice its weight of carbonated ſoda, and kept in a moderate heat for two hours. When the maſs had cooled, it was powdered, ſuper-ſaturated, and digeſted with dilute muriatic acid. This done, the muriatic fluïd filtered off from the *ſiliceous earth*, that had much ſwelled, together with the lixiviating water, was concentrated by evaporation, and ſaturated with cauſtic ammoniac; by which, however, only a ſmall precipitate was produced, conſiſting of pure *alumine*, unmixed with iron, and weighing $1\frac{5}{8}$ grains after ignition. Nothing farther was found in the remaining liquor.

Hundred parts of this *hydrophanes*, from *Saxony*, therefore contain:

Silex	93,125
Alumine	1,625
Volatile inflammable parts, and *water*	5,250
	100

If this hydrophanes, after complete expulſion of its aqueous moiſture, be ſteeped in melted wax or ſpermaceti, in which ſtate of artificial preparation it is called *pyrophanes*; it acquires the property of being quite tranſlucid, and of a brown yellow or grey colour, when heated in a ſpoon upon a charcoal fire.

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XLVII.

CHEMICAL EXAMINATION
OF THE
WHITE AND GREEN OPAL
From Koſemütz *.

AMONG the different ſtones that accompany the chryſopraſe in its veins, on the mountainous diſtrict of *Koſemütz*, there alſo occur various ſorts of opal, which ought to be claſſed partly with the *common* (dull) *opal*, partly with the *ſemi-opal*. They are there found chiefly of four colours, viz. green, reddiſh, yellow, and milk-white; of which the three laſt varieties belong to the *common-opal*, and moſtly lie on a grey and browniſh hornſtone.

The ſubject of this enquiry was the *milk-white*, *inclining to the blueiſh and tranſparent* variety of that *common-opal*.

a) *Half an ounce* of this foſſil, moſt finely levigated, and intimately mingled with one ounce of deſiccated ſoda, was moderately ignited for two hours. The maſs, obtained and ground to powder, was ſaturated to exceſs with dilute muriatic acid; then evaporated nearly to dryneſs, again diluted with water, and finally thrown upon the filter The reſidue, lixiviated, dried, and ignited, gave 237 grains of *ſiliceous earth*.

b) The fluid, diminiſhed by evaporation, and combined with cauſtic ammoniac, afforded a ſlight quantity of a browniſh precipitate. As the remaining liquor continued unaltered, on being combined with carbonat of ſoda, it ſhewed, by this, that it held no other ſubſtance in ſolution.

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* *Beobachtungen und Entdeckungen aus der Naturkunde.* Berlin, 1788. vol. II. page 45.

e) When the precipitate, obtained by means of cauſtic ammoniac, had been rediſſolved in muriatic acid, and treated with pruſſiat of pot-aſh; it afforded ſome Pruſſian blue, of which the *oxyd of iron*, that enters as a conſtituent part into this opal, was, at moſt, one-quarter of a grain. After its ſeparation, carbonat of ſoda ſtill precipitated half a grain of *aluminous earth*, which, upon ignition, could not be eſtimated at more than one-quarter of a grain.

This *common opal*, therefore, chiefly conſiſts of mere ſiliceous earth; for *one half* ounce of it yielded:

Silex	237 grains.
Alumine	0,25
Oxyd of iron . . .	0,25
	237,50
Loſs . .	2,50
	240 grs. or ½ oz.

The *apple-green* variety of thoſe opals from *Koſemütz*, which it will be more proper to rank under the *ſemi-opal*, penetrates like the chryſopraſe, in clefts or veins, of from one-half to one full inch thickneſs, thoſe maſſes of earths and ſtones, which lie promiſcuouſly in irregular ſtrata in the mountains which afford chryſopraſe. The conſtituent parts of this green ſemi-opal are likewiſe thoſe of the foregoing common white opal, only that it contains about *one per cent.* of *oxyded nickel*, from which, likewiſe, its green colour, like that of chryſopraſe, originates.

XLVIII.

CHEMICAL EXAMINATION

OF THE

YELLOW OPAL from Telkebanya.

FOR the analyſis of this ſpecies of opal, expreſſed by the name *pitch-opal*, *telkebanya-ſtone*, I ſelected that clear greeniſh-yellow variety, which in groſs ſplinters reſembles the *bright-yellow* common *amber* (electrum, ſuccinum).

a) *Hundred* grains of it, broken into coarſe fragments, were ſubjected to red-heat for half an hour in a covered crucible. The ſtone flew in pieces, with a moderate decrepitation or crackling noiſe. It was ſlightly tranſparent, after this ignition, but only on the edges; its colour alſo changed into a pale brown-yellow, and the loſs of weight, which it ſuſtained, amounted to five grains. At the ſame time it became very ſoft, and allowed of being eaſily ground to a ſubtle iſabella-yellow powder.

A ſtronger heat renders this opal greyiſh-white. The ſlight portion of iron which it contains, and from which it derived its colour, is reduced, in this proceſs, to the reguline ſtate; and, by means of a good magnifying lens, extremely fine grains of iron, that have tranſuded, may then be diſcovered *.

b) The above-mentioned 95 grains of ignited and pulverized opal were mixed with 200 grains of effloreſced mild

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See Eſſay I. No. 66.

ſoda, or ſuch as had loſt its water of cryſtallization in the air; and in that ſituation expoſed to, and maintained in, a moderate red-heat during the ſpace of one hour. The mixture came out of the fire quite white, and but looſely conglutinated. It was next ſoftened with water; ſuperſaturated with muriatic acid; concentrated by evaporation to a jelly; once more diluted with water; and, laſtly, thrown upon the filter. The *ſiliceous earth*, which, by this management, remained behind on the paper, weighed 93½ grains, when ignited.

c) I then treated the colourleſs muriatic fluid with cauſtic ammoniac, added in an over proportion. But only a few brown flakes ſeparated, which, when collected and ignited, afforded one grain of oxyd of iron. The remainder of the fluid contained no other ingredient.

Accordingly, *hundred* grains of this *yellow opal*, from *Telkebanya*, conſiſt of:

Silex	93,50
Oxyd of iron . . .	1
Water	5
	99,50

XLIX

XLIX.

CHEMICAL EXAMINATION

OF THE

BROWN-RED SEMI-OPAL

From Telkebanya.

THIS foſſil, which occurs but ſeldom in the Telkebanya-mountains, and by ſome has been erroneouſly conſidered as a red pitch-ſtone, poſſeſſes a brown-red colour; is maſſive, and of moderate brilliance. Its fracture is flat conchoidal, and its texture compact and ſmooth. It is opake, brittle, and burſts eaſily. By reduction to a fine pulverulent ſtate, it acquires a fully ſaturated deep-red colour, ſimilar to that of powdered reſin, called dragon's-blood. Its ſpecific gravity I found to be 2,540.

a) When entire pieces of it were ſtrongly ignited for half an hour, in a covered crucible, it neither flew in pieces, nor experienced any change of colour; but it loſt 7½ *per cent.* of weight.

But when expoſed to the more intenſe heat of the porcelain furnace, the phenomena take place, which have been mentioned in Eſſay I. No. 65. For, if ignited in the *charcoal crucible*, a great number of grains of iron tranſude, and the fracture of the ſtone becomes grey, dull, earthy, very rough and porous, like ſpunge. If ignited in the *clay-crucible*, its whole ſurface is covered by a fine-ſcaly ferruginous cruſt, of a metallic luſtre, and attractible by the load-ſtone. It is, indeed, an unexpected phenomenon, and hence the more remarkable, that iron, ſo ſtrongly oxyded as it is when contained in this foſſil, has, in the latter inſtance, been reduced to the reguline ſtate, ſo as to obey the magnet; and this, without any admixture of charcoal, or any other ſubſtance of a nearer affinity with oxygen.

b) *Hundred* grains of the foſſil, moſt finely levigated, were mixed with a cauſtic alkaline lye, containing 300 grains of the ſalt. This mixture, being firſt inſpiſſated to dryneſs in a ſilver veſſel, was then ignited for half an hour. After re-frigeration, I ſoftened the maſs with water, ſuperſaturated it to a great exceſs with muriatic acid; and having inſpiſſated it to a gelatinous conſiſtence, I diluted it again with water, digeſted and filtered it. The *ſiliceous earth*, then obtained and ignited, weighed 43½ grains.

c) The yellow muriatic ſolution was combined with cauſtic ammoniac to over-ſaturation. A quantity of brown *oxyd of iron*, rather in large proportion, fell down, which weighed 47lb. when waſhed, dried, and ignited. The fluid left by this remained unchanged, when combined with mild alkalis.

d) This oxyd of iron was re-diſſolved by digeſtion, in muriatic acid, and precipitated by Pruſſian alkali. After the ſeparation of this blue precipitate of iron, the remaining ſolution was examined, firſt with cauſtic ammoniac, and next with mild ſoda. It ſuffered no change in either caſe.

Wherefore this foſſil, which, from its large proportion of iron, might, perhaps, deſerve to be claſſed under the genus of iron, with the denomination of *opaline iron ſtone*, is, in the *hundred*, compoſed of:

Oxyd of iron	47
Silex	43,50
Water	7,50
	98

L.

L.

CHEMICAL EXAMINATION
OF
*MENILITE**.

THE foſſil here treated of, and of which *Delabre* and *Quinquet* have given the firſt notice †, is found at *Menilmontant*, near *Paris*. It there occurs at a depth from 60 to 80 feet under a ſeam of clay (*Thonbank*), in a ſtratum of ſtones that belong to *Werner's poliſhing ſlate*, and is found in larger or ſmaller pieces, for the moſt part detached, and kidney form, or rather in nodules. The colour of its external ſurface is a tarniſhed blue; but its fracture is of a hair-brown, with ſome greaſy luſtre. Its texture appears externally foliated or fine-ſlaty. This, however, is to be conſidered merely as impreſſions from the adhering finely-lamellated *gangue* or matrix; and ſhould be diſtinguiſhed from the coarſe ſlaty texture of the ſtone itſelf, which can only be obſerved when ſeparate. It readily burſts into fragments, which are flat-conchoidal in the croſs fracture, but coarſe-ſplintery in the longitudinal fracture, and are tranſparent in the edges. It cuts glaſs, though it greatly yields to the file, which produces a grey-white ſtreak on it. When it is ſtruck with ſteel, only a few ſingle ſparks are emitted. Its ſpecific gravity is 2,185.

In the ſyſtematical arrangement of minerals, this ſtone has formerly been reckoned among the genus of clay, and accordingly placed as a variety of pitch-ſtone, with the name *blue pitch-ſtone*. Againſt this, an anonymous author has

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* *Chemiſch. Annal.* 1790. 2 Th. S. 297.

† *Journal de Phyſique*, Paris, Sept. 1787.

ſtarted

ſtarted ſome doubts, in a letter to *de la Metherie*[‡], in conſequence of experiments which he has made, by moiſtening ſome pieces of the ſtone, and expoſing them for ſeveral months to open air; upon which he found, that ſulphat of magneſia had gradually been formed. By this he was perſuaded, that this ſpecies of ſtone belongs to the magneſian genus, and ſhould be added to the ſteatites, ſerpentine and pot-ſtone. With what propriety, will appear from what follows.

A.

From the pieces choſen for this enquiry I firſt ſeparated the earth adhering to their outſide. I then introduced *hundred* grains into a ſmall glaſs retort, inſerting its neck into a bottle containing lime-water. The retort was placed between the coals, or in open fire, and the heat gradually increaſed to the ignition of its contents. At the very beginning there paſſed over ſome drops of water, and ſoon after I ſaw the lime-water in the receiver growing turbid. In this laſt, when the receiver had been removed, I perceived a bituminous-empyreumatic ſmell, which, at firſt, alſo ſeemed to be ſomewhat ammoniacal. The pieces of the ſtone in the retort were rendered black and reſplendent, like jet *(Gagas)*, and had loſt eight grains. But by a ſtill ſtronger ignition in an open crucible, they loſt again that black colour, and became at firſt blueiſh, then grey-white, loſing, at the ſame time, three grains more in weight.

I then combined them, previouſly ground to fine powder, with double their quantity of carbonated pot-aſh, and put them into an open fire, in a ſilver crucible. The mixture entered into fuſion, without my intending it, and foamed ſo

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[*] *Journal de Phyſique*, Paris, Fevr. 1789.

ſtrongly that it lifted up the lid of the veſſel, and run over in part. Seeing this, I directly withdrew the crucible from the fire, and found that the remaining portion of the maſs had melted into a clear greeniſh glaſs; which, as it cooled, attracted moiſture from the air, and diſſolved entirely in a little water.

Although I could not farther proceed in this examination, on account of having loſt part of the maſs; yet I foreſaw, from theſe facts, that this foſſil is not a very compounded ſpecies of ſtone, but rather that it is likely to conſiſt almoſt entirely of mere ſiliceous earth. This conjecture was again confirmed by the following experiment.

B.

a) I reduced *one hundred* grains of the rough ſtone to an impalpable powder; and having mixed them with twice their weight of carbonated pot-aſh, I ignited the mixture in a ſilver crucible, during five hours, in a degree of heat ſo moderate, that there was no danger of its fuſing. When triturated, it diſſolved in water, aſſiſted by heat, leaving only a few undiſſolved particles. By ſuper-ſaturation with muriatic acid, the mixture congealed to a thick, intumeſced ſlime. After farther dilution with water, digeſtion, and filtering, there remained 84 grains of *ſiliceous earth*, upon being waſhed, dried, and heated to redneſs.

b) When the fluid, ſeparated from this laſt, had been concentrated by evaporation, and, while yet hot, ſaturated with mild ſoda, a browniſh-white precipitate fell down; which, being re-diſſolved in nitro-muriatic acid, there ſtill ſeparated ſome *ſiliceous earth*, weighing 1½ grain, when ignited.

c) The liquor, freed from this, was treated with Pruſſian alkali; and the quantity of the blue precipitate then produced indicated half a grain of *oxyd of iron*, attractible by the magnet. After the ſeparation of this laſt, *aluminous earth*, weighing one grain in the ignited ſtate, was thrown down by cauſtic ammoniac. Carbonated ſoda, with the aſſiſtance of heat, precipitated from the remaining fluid a ſlight portion of looſe earth; which, after ignition, ſcarcely weighed half a grain, and, upon trial by ſulphuric acid, ſhowed itſelf to be *calcareous earth*, accompanied by a trace of *magneſia*.

In conſequence of this analyſis, *hundred* parts of *menilite* contain:

Silex	85,50
Alumine	1
Oxyd of iron	0,50
Lime	0,50
Water and carbonic matter	11,
	98,50

From the conſtituent parts here produced, it is obvious, that this foſſil can, by no means, belong to ſteatites, or to ſerpentine, or to the pitch-ſtone, as the proportions of thoſe ingredients, in conjunction with the infuſibility of *menilite*[*], ſufficiently prove. Perhaps this foſſil may be conſidered as a variety of the *ſemi-opal*, approaching to flint (*Feuerſtein*).

The inconſiderable trace of magneſia does not ſeem to belong to the mixture or compoſition of this foſſil. It rather originates from particles, that have entered into it from its matrix, which contains a ſmall portion of magneſia, as will appear by the following analyſis.

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[*] See Eſſay I. No. 69.

LI.

CHEMICAL EXAMINATION OF THE *POLISHING-SLATE*

(Polierſchiefer of Werner.)

*From Menil-montant.**

THE *poliſhing-ſlate*, found at *Menil-montant*, which ſerves as a matrix to the *menilite*, ſpoken of in the laſt Eſſay, poſſeſſes a bright white-grey colour; is meager and rough; of a dull earthy fracture; ſtrongly adhering to the tongue; and ſplit, in a ſlaty manner, by ſlender horizontal rifts. Its ſpecific gravity is only 2,080. When thrown into water, it imbibes it with a crackling noiſe, and copious air-bubbles are diſengaged. By trituration it affords a very looſe powder, which, on ignition, loſes 19 in the hundred, and acquires thereby a pale red colour.

I ſhall not relate in detail the method by which I performed its decompoſition, as it was the ſame with that of the preceding foſſil. But I ſhall only mention the reſult, according to which the conſtituent parts of *poliſhing-ſlate*, and their proportions to one another, in the hundred, are:

Silex	66,50
Alumine	7
Oxyd of iron	2,50
Magneſia	1,50
Lime	1,25
Water	19
	97,75

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* Chemiſche Annalen, 1790. 2ter Theil, Seite 302.

LII.

CHEMICAL EXAMINATION

OF THE

SILICI-MURITE. (Meerſchaum.)

From the Levant *

THE plaſtic *ſilici-murite (myrſen, kil, keffekil)* from *Eſki-Scheher*, in *Natolia*, the external characters of which, along with ſome obſervations upon it, have been given by *Karſten* †, ſhould, on account of its exterior appearance, be rather added to the argillaceous genus, and in particular to the ſpecies of tripoli, than to the genus of magneſian earths, under which it has been placed ſince its analyſis, publiſhed by *Wiegleb* ‡

However, as it appears from the paper of *Wiegleb*, that the ſilici-murite decompoſed by him was not then in its crude native form, but had been wrought into tobacco-pipe heads, and as from this circumſtance it might become doubtful whether the foſſil, employed by him in that ſtate, was genuine; I thought it of ſome uſe to repeat his enquiry, by analyſing ſome genuine ſilici-murite in its natural ſtate.

For this purpoſe I ſelected two varieties; the firſt of which differed from the other, by a whiter colour, a ſomewhat ſmaller degree of hardneſs, and a greater looſeneſs when powdered.

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* *Beob. u. Entd. a. d. Naturkunde*, vol. V. Berlin, 1794, page 149.

† Loc. cit. page 143.

‡ *Neuſte Entdeckungen in der Chemie*, 5 Theil. Seite. 3.

A.

A.

a) The ſpecific gravity of the whiter variety in pure lumps, freed from their porphyraceous matrix, is 1,600. Of this I ſubjected *hundred* grains to a briſk red-heat in a crucible, by which they loſt 30 grains. But, in other reſpects, they ſuffered no alteration obſervable in their external appearance: as, by the reſult of a previous experiment, hereafter to be mentioned, the loſs of weight, which this foſſil ſuſtains by ignition, is five parts of water and one of carbonic acid. The above loſs of 30 grains is, conſequently, divided into 25 grains of *water* and five grains of *carbonic acid.*

b) The remaining ignited 70 grains were ground to a moſt ſubtle powder, which I firſt worked with water to a pulpy conſiſtence. Half an ounce of ſtrong ſulphuric acid was then added, and all the fluid diſtilled over to dryneſs. The reſidue being ſoftened with boiling water, its undiſſolved portion was ſeparated by means of the filter. Which laſt, edulcorated, dried, and ignited, conſiſted of 50½ grains of white, very looſe *ſiliceous earth.*

c) The clear, colourleſs liquor ſhewed, by the taſte, that it was a ſolution of *ſulphated magneſia.* When concentrated by evaporation, it depoſited, as it cooled, a ſmall quantity of ſelenite, in tender ſpear-ſhaped cryſtals. This being decompoſed by mild ammoniac, afforded one grain of carbonated lime, for which half a grain of pure *calcareous earth* muſt be reckoned.

d) When the ſelenite or ſulphated lime had been ſeparated, the ſolution yielded, by cryſtallization, only ſulphat of magneſia. From this ſalt, re-diſſolved in water, and decompoſed in a boiling heat, by carbonat of pot-aſh, 37½ grains of carbonated magneſia were obtained, which were reduced, after an hour's ignition, to 17¼ of pure *magneſia.*

An *hundred* parts of this *whiter ſilici-murite*, therefore, contain:

Silex . . .	*b*) . . .	50,50
Magneſia . . .	*d*) . . .	17,25
Lime	*c*) . . .	0,50
Water	*a*) . . .	25
Carbonic acid . .	*a*) . . .	5
		98,25

I could not aſcertain, in the *humid way*, the proportion of the carbonic acid ingredient in this foſſil; ſince acids do not completely diſſolve or decompoſe it in the cold, and hence do not at all efferveſce with it, or only imperceptibly. For this reaſon, I attempted it in the *dry way*. I introduced 200 grains of pulverized ſilici-murite into a ſmall glaſs retort, connected with the hydrargyro-pneumatic apparatus, and kept it in ignition until the veſſel was near fuſing. The water that paſſed over I collected in the intermediate ſmall ſpherical cavity of the conducting pipe, while the gas was caught in a receiver above the mercury. The water weighed 35 grains. It was yellowiſh, and emitted a ſmell like petroleum; it alſo manifeſted an obſcure veſtige of ammoniac, which, however, was ſoon after ſucceeded by a feeble trace of an acid. But the gas, deducting the common air contained in the apparatus, amounted to 13 cubic inches, whoſe weight is nearly ſeven grains. This was entirely abſorbed by lime-water, from which it precipitated carbonated lime or crude calcareous earth.

B.

The *other ſort of ſilici-murite*, the colour of which inclined to the grey, loſt 39 grains in the *hundred*, and acquired by it

the

whiteneſs of chalk. Its decompoſition was performed in the ſame manner as that of the foregoing. In the reſult, the folloing appeared to be its conſtituent parts in the *hundred*:

Silex	41
Magneſia	18,25
Lime	0,50
Water and carbonic acid, .	39
	98,75

Beſides theſe two varieties of ſilici-murite, I have likewiſe analyſed a third, in which I have found the proportion of magneſia conſiderably greater, but that of ſilex much ſmaller in the ſame ratio. But as this conſiſted of one ſingle fragment only, I was not able to repeat the experiment. Yet I mention this, becauſe it ſhews that Nature does not always obſerve an invariable proportion in the two chief conſtituent parts of ſilici-murite; as, indeed, is alſo the caſe with reſpect to various other foſſils.

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LIII.

CHEMICAL EXAMINATION
OF THE
SEMI-INDURATED STEATITES.

(Speckſtein of Werner.)

From Bareuth.

THOUGH the *common Steatites*, which occurs at *Göpfersgrün*, near *Wunſiedel*, in the principality of *Bareuth*, is found in conſiderable quantity, yet it has till now been met with only in detached, larger or ſmaller, reniform lumps. It is diſtinguiſhed from other ſpecies of ſtones of the ſame genus particularly by this, that it is found ſometimes in hexahedral priſmatic cryſtals, with ſix-ſided pyramidal terminations, and, but very lately, in double hexahedral pyramids*, imbedded in maſſive indurated ſteatites.

a) *Two hundred* grains of this ſteatites, finely ſcraped by the knife, were ſubjected to red-heat, in a covered crucible, during one hour. They loſt by this 11 grains of weight, and the ignited powder of the ſtone received an iſabella-yellow colour.

b) This powder I mixed in a ſilver-crucible with a cauſtic lye, of which the alkaline part, or the pot-aſh, was double the weight of the pulverized ſtone; and, after having evaporated it to drynes, I kept it in ignition for half an hour. This maſs was again diſſolved in water, and digeſted with muriatic acid, added in exceſs. *Siliceous earth* was thus ſeparated, amounting to 119 grains, after waſhing, drying, and ignition.

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* This rare cryſtallization of the *Bareuth-ſteatites*, reſembling the double hexahedral, calcareous, Derbyſhire-ſpar, is found in the collection of Mr. *Frick*, Maſter of the Mint at Berlin.

c) The muriatic ſolution was combined with carbonat of pot-aſh, heated to the degree of ebullition. The browniſh precipitate, thereby produced, was treated with muriatic acid; the ſolution evaporated, and the dry ſaline maſs ſtrongly ignited during half an hour. Having re-diſſolved this ſaline maſs in water, and ſeparated the brown oxyd of iron by filtration, I combined the clear ſolution with carbonated pot-aſh, at the temperature of boiling. By theſe means, 147 grains of very looſe and white *magneſia* were precipitated. One half of this, re-diſſolved in ſulphuric acid, and cryſtallized, afforded pure ſulphat of magneſia. The other half, when heated to redneſs, weighed 30½ grains.

d) The brown-red oxyd of iron, that had ſeparated from the aqueous ſolution of the ignited ſaline maſs (*c*), weighed nine grains. But, as the portion of iron, exiſting in the mixture of ſteatites cannot be conſidered as perfectly oxyded, but only as being in the ſtate of an oxyd of iron, ſtill attractible by the magnet, I deflagrated linſeed-oil upon it, in a covered crucible.—This *oxyd of iron* now weighed only five grains.

According to this analyſis, the *Steatites* from *Bareuth* conſiſts, in *hundred* parts, of:

Silex	*b*)	59,50
Magneſia	*c*)	30,50
Oxyd of iron	*d*)	2,50
Aqueous particles, driven out by a red-heat		5,50
		98

LIV.

LIV.

CHEMICAL EXAMINATION
OF THE
STEATITES FROM CORNWALL[*].

(Soap-rock, Seifenſtein.)

THE *Steatites* of *Cornwall* (*Talcum Smectis, Lin.*) occurs at the Cape *Lizard*, in ſerpentine mountains, which it cuts through in ſmall, perpendicular, or *rake veins*. The fineſt ſort of it is white, with blueiſh, or reddiſh ſpots, reſembling marble. While freſh from the mine, [illegible] is ſo ſoft, that, like ſoap, it may be abraded with the knife. It is uſed in making porcelain. The working of theſe mines is carried on by the Houſe of the Porcelain-manufacture at *Worceſter*; which pays 20l. ſterling for the ton, at 20 cwt.; becauſe, the bringing it out to the day is extremely uncertain and dangerous, the ſerpentine rock breaking in ſo frequently. There alſo occurs in theſe mines another ſort of it, leſs fine, and having ſpots of iron-ochre; as well as a third, brown-red variety, mingled with green. Not far from thence, at *Ruan minor*, alſo in ſerpentine, there is found, both a grey-white and a light-ſlate-blue ſoap-rock, or ſteatites, and alſo a whitiſh ſteatites, croſſed by calcareous ſpar, which gives it a ſmooth, ſhining fracture.

It was the firſt, fineſt ſort of ſteatites, that was the ſubject of the following analyſis.

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[*] *Beobacht. u. Entdeck. a. d. Naturkunde*, vol. I. Berlin, 1787, pages 163 and 192.

a) *One ounce* of it, in ſelected pieces, was expoſed to an intenſe red-heat, placing the glaſs-retort in open fire. There diſtilled over a little pure taſteleſs water. The ſteatites loſt thereby 75 grains, and acquired a ſomewhat darker colour, and a conſiderable degree of hardneſs.

b) It was next, after previous pulverization, intimately mingled and ignited with two ounces of carbonat of potaſh in a porcelain-pot. The concreted maſs was levigated with water, and digeſted with an over-proportion of muriatic acid. By this, a large quantity of a white, looſe, ſlimy earth, ſubſided; which, upon edulcoration, drying, and expoſure to red-heat, weighed 204 grains, and was pure *ſiliceous earth.*

c) When the filtered ſolution had been combined with Pruſſian alkali, a blue precipitate aroſe, which I collected, waſhed, dried, and ignited with a little wax. The whole of it obeyed the magnet, and weighed ſeven grains; of which, ſubtracting the portion of iron belonging to the pruſſiated pot-aſh employed, 3½ grains are the *oxyd of iron*, entering as a conſtituent part into ſteatites.

d) From the ſolution, freed from iron, I now precipitated its earthy ingredient, by carbonated pot-aſh. It weighed 192 grains, when waſhed, and gently ignited. Theſe were covered with a proportionate quantity of diſtilled vinegar, ſomewhat concentrated by freezing; and, after this, digeſted in a low heat, and thrown upon the filter. The earth that remained on the paper, and which weighed 93 grains, when deſiccated and ignited, was mixed with three times its weight of ſtrong ſulphuric acid; the mixture evaporated nearly to dryneſs in a ſand-heat; the dry ſaline maſs liquefied in water; and, laſtly, filtered. By this treatment there yet remained 26 grains of *ſiliceous earth.*

e) The ſulphuric ſolution (*d*), therefore, contained 67 grains of earth; which, precipitated by alkali, and examined in the uſual way, was found to be merely *aluminous earth.*

f) Of the firſt 192 grains of the earthy precipitate (*d*), 99 grains were taken up by the acetic acid. Theſe I likewiſe precipitated by means of carbonated pot-aſh. The earth thus obtained, was tried by ſulphuric acid, and found to be mere *magneſia.*

Therefore *one ounce*, or 480 grains, of this *Steatites from Cornwall* have yielded:

Silex	*b*)	204 grs.	. : 230 grs.
——	*d*)	26	
Magneſia . .	*f*)	. . . .	99
Alumine	*e*)	. . . . . .	67
Oxyd of iron .	*c*)	. . . .	3,75
Water	*a*)	. . . .	75
			474,75
		Loſs .	5,25
			480

Or, an *hundred* parts of it, averaging the ſmall fractions, contain:

Silex	48
Magneſia	20,50
Alumine	14
Oxyd of iron	1
Water . . . . :	15,50
	99

LV.

CHEMICAL EXAMINATION

OF THE

CHINESE AGALMATOLITE.

(Plaſtic ſtone. Bildſtein.)

BY the name *Plaſtic-Stone* (agalmatolithus), I denote that foſſil, which hitherto has been called *Steatites* from *China*; ſince this laſt denomination of it, as indicating a ſtone belonging to the magneſian, or muriatic genus, can no longer be retained with propriety, as will appear from the following analyſis of that foſſil.

The want of rough pieces of this ſtone I ſupplied by employing figures cut of it; the genuineneſs of which is rendered indiſputable by the known peculiar taſte or *character* of the Chineſe art.

On breaking ſeveral of theſe little carved figures, I obſerved that two varieties may be diſtinguiſhed of the ſtone uſed for them by the Chineſe artiſts; which I denominate the *tranſparent* and the *opake*.

A.

Tranſparent Chineſe Agalmatolite.

The colour of this is olive and aſparagus-green, verging through various ſhades to a greeniſh-blue. Inwardly it is very much glittering, and of a greaſy luſtre. The chief fracture is indiſtinctly thick-ſlaty, but the croſs-fracture evidently ſmall-ſplintery. It is ſtrongly tranſparent, inclining to the ſemi-tranſlucid; ſoft, and of a greaſy feel, &c. Its ſpecific gravity, 2,815.

a) Two hundred grains of this agalmatolite, finely ground, loſt 11 grains of weight by a moderate ignition for half an hour.

b) After the firſt ignition, the powder of the ſtone was mixed with equal parts of carbonated ſoda, and once more ſubjected to red-heat for half an hour in a ſilver-crucible. The mixture returned from the fire in the form of a moderately coaleſced powder. I diluted it with water, and ſuper-ſaturated it with muriatic acid; which diſſolved the whole of it without leaving any obſervable reſidue. But when the ſolution had been put in a ſand-heat to evaporate, it formed a thick gelatinous coagulum; and after digeſting it for ſome time, it was filtered. The collected *ſiliceous earth*, waſhed and ignited, weighed 105½ grains.

c) The muriatic ſolution, ſaturated with cauſtic lixivium, thickened to a milk-white maſs. By a ſlight exceſs of the alkaline lye, it again diſſolved entirely to a limpid, colourleſs fluid, leaving only a few light-brown, looſe flakes, which, upon edulcoration and ignition, weighed four grains.

d) Theſe four grains of brown reſidue were treated by digeſtion with muriatic acid. *Siliceous earth*, weighing 2½ grains in the ignited ſtate, was then ſeparated. This done, the ſolution was combined with pruſſiat of pot-aſh, and the blue ferruginous precipitate, thereby produced, was collected. Nothing elſe was found in the remaining fluid. The portion of iron, which it contained before, amounted to 1½ grain.

e) The alkaline ſolution (*c*) was ſaturated to exceſs with ſulphuric acid, and then combined, in a boiling heat, with carbonated ſoda, to precipitate its earthy contents. The earth, thus obtained, was lixiviated and dried; and afterwards depurated by means of diſtilled vinegar and ammoniac. Upon deſiccation, it weighed 122 grains; but upon ignition, only 72. It was found to be pure *aluminous earth*; for, when re-diſſolved in ſulphuric acid, and cryſtallized with an adequate proportion of acetated pot-aſh, it afforded only ſulphat of alumine.

Wherefore, the *tranſparent* variety of the *Chineſe agalmatolite*, calculated for *an hundred* parts, contains:

Silex	*b*)	52¾	
——	*d*)	1¼	
		54	54
Alumine	*e*)		36
Oxyd of iron	*d*)		0,75
Water	*a*)		5,50
			96,25

B.

Opake Chineſe Agalmatolite.

This variety of agalmatolite is reddiſh-white, fleſh-red, and of variouſly coloured veins. Its fracture is dull, and leſs diſtinctly ſplintery. It is opake, or only very little tranſparent on the edges; very ſoft; and feels very greaſy. The ſpecific gravity of it is 2,785.

a) *Two hundred* grains of it, finely ſcraped off from the maſs, ſuſtained a loſs of 20 grains by ignition. Its original reddiſh-white colour was by this proceſs changed to a grey.

b) This ignited powder was a ſecond time expoſed to red-heat for half an hour, in a ſilver-cruible, with its own quantity of deſiccated mild ſoda; which cauſed it to conglutinate but moderately. The mixture, previouſly drenched with water, was combined with an over-proportion of muriatic acid, and the ſolution evaporated to a jelly.—When this had again been diluted with ſufficient water, it depoſited *ſiliceous earth*, amounting to 122 grains, when collected on the filtering paper, and ſubſequently lixiviated and ignited.

c) The muriatic ſolution was afterwards decompoſed by carbonated pot-aſh, and the thorough ſeparation of the precipitating earth was promoted by boiling. The precipitate, which ſubſided in a highly ſwelled ſtate, was lixiviated, and while yet moiſt, brought into a warmed alkaline cauſtic lye; in which it diſſolved in an inſtant, and left only a ſlight browniſh reſidue.

d) Muriatic acid entirely diſſolved this reſidue. By combination with Pruſſian alkali, Pruſſian blue fell down, the quantity of which denoted one grain of *iron* in the ſtone. The fluid was next, after the ſeparation of the iron, decompoſed in a boiling heat by diſſolved carbonat of pot-aſh, which precipitated a white earth. This laſt efferveſced moderately with ſulphuric acid that was poured upon it, and depoſited gypſum; the quantity of which increaſed, in proportion as the volume of the mixture was reduced by evaporation. It weighed, after ignition, five grains, equal to two grains of pure *calcareous earth* in the ignited ſtate. The ſmall quantity of the fluid yet remaining ſhot into cryſtals of ſulphat of alumine.

e) The portion which had been taken up by the alkaline lye (*c*) was thrown down by means of ſulphuric acid, but

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it diſſolved again by a ſlight exceſs of the ſolvent. The alum laſt obtained, (*d*), was then added to it, and the whole precipitated afreſh by carbonat of pot-aſh, aſſiſted by a boiling heat. When afterwards edulcorated, dried, purified by means of vinegar and ammoniac, and finally heated to redneſs, the precipitated alumine weighed 50 grains.

f) I then poured ſulphuric acid upon it, and inſpiſſated the mixture on a ſand-bath. The turbidneſs of the fluid, on being again diſſolved in water, was cauſed by the tender *ſiliceous earth*, which then ſeparated, and conſiſted of two grains after ignition. This being ſubtracted, the quantity of *aluminous earth* (*e*) is reduced to 48 grains; which now, by combination with acetite of pot-aſh, and cryſtallization, continued to the end to ſhoot into alum only.

It follows, from this decompoſition of the opake variety of the *Chineſe agalmatolite*, that its conſtituent parts give in the *hundred*:

Silex	*b*)	61	62
——	*f*)	1	
Alumine	*f*)		24
Lime	*d*)		1
Oxyd of iron	*d*)		0,50
Water	*a*)		10
			97,50

Several examples have ſhewn, that, in the ſyſtematical arrangement of foſſils, the light of chemiſtry ſhould be the guide; and I think the preſent analyſis furniſhes one of the moſt conſpicuous proofs of that point. The three foſſils, which were the ſubject of this and the two preceding eſſays, have to this day been conſidered merely as varieties of *ſteatites*: and yet, how materially do they differ in their conſtituent parts, conſidering that the ſemi-indurated ſteatites (*Speckſtein*), from *Bareuth*, contains, beſides its portion of *ſilex*, merely *magneſia*; that the ſteatites (*Seifenſtein*), from *Cornwall*, is compoſed of *magneſia* and *alumine*; and that the *Chineſe* ſteatites (*Bildſtein*, *agalmatolite*) contains alſo *alumine*, but not the leaſt trace of *magneſia*. This laſt, which muſt now be removed from the genus of magneſia, and added to that of alumine, ſeems to be properly placed along with lithomarga (*Steinmark*).

Among the other ſtones, alſo manufactured by the Chineſe into figures, or little ſtatues, I have likewiſe met with a white, pure, very finely grained *marble*; which, by bare inſpection, is ſufficiently diſtinguiſhed from the Chineſe agalmatolite here treated of.

LVI.

ADDITION
TO THE
CHEMICAL EXAMINATION
OF
LEPIDOLITE[*].

SINCE the analyſis of *Leucite*, deſcribed in the earlier part of this work, has evidently proved that it contains the *vegetable alkali* as one of its eſſential conſtituent parts; it was to be expected that this alkaline ſubſtance might likewiſe be found in the mixture of various other ſpecies of ſtones and earths. The firſt confirmation of this conjecture has been afforded to me by the *Lepidolite*.

In the examination of this ſtone, here quoted, the loſs of weight in the ſum of its conſtituent parts, which I could not then farther account for, amounted to 6½ *per cent.*[†] As I ſuſpected that this loſs might ariſe from the vegetable alkali, which at that time was not yet known as a co-conſtituent part of foſſils, I reſolved to undertake a ſecond analyſis of lepidolite.

A.

I reduced, by grinding, 250 parts of the *amethyſtine red lepidolite* to as fine a powder as the hardneſs and lubricity of its

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[*] *Eſſay* XIX. page 238.

[†] See *Eſſay* XXXII. page 355 ſeq.

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its ſcaly aggregate particles would allow, and digeſted it with a large quantity of muriatic acid, in a temperature raiſed at intervals to the point of ebullition. The remaining powder of the ſtone, when ſeparated from the muriatic ſolution and waſhed, was deſiccated and ignited. It ſtill appeared, as before, in the form of white, very delicate ſhining ſcales, and weighed 210 grains. Treated with the blowpipe, it fuſed, nearly as eaſily as lepidolite in the rough ſtate, to a ſmooth globule.

b) This circumſtance making it evident that the muriatic acid had effected only an incomplete decompoſition, I reduced again the remaining powder, by long continued trituration, to the moſt comminuted ſtate poſſible, and boiled it once more with a freſh quantity of muriatic acid. The reſidue ſeparated by filtration ſhewed now no farther diſpoſition to melt, and ſeemed to conſiſt of mere ſiliceous earth.

c) The muriatic ſolutions (*a*) and (*b*) were then evaporated to dryneſs, in a ſand-heat; the ſaline maſs remaining was pulverized, covered with alkohol, and placed in a warm temperature. A conſiderable ſediment ſettled to the bottom; which, after the ſpirituous ſolution had been poured off, was diſſolved in water, combined with ſome drops of ammoniac, and filtered. It then left behind it a browniſh ſlime, conſiſting of alumine, ſilex, and oxyd of mangeneſe.

d) I next evaporated the clear ſolution that had paſſed the filter. It left behind a ſaline pellicle, conſiſting of ſmall cubes; which, after gentle ignition, in order to drive off the ſmall portion of muriated ammoniac exiſting in it, weighed 16½ grains. This ſalt was muriated pot-aſh. Diſſolved in a little water, and combined with a ſolution of pure tartareous acid, it formed acidulous tartrite of pot-aſh, *(cream of tartar)*, which by combuſtion yielded carbonat of pot-aſh.

Now, ſince in 16½ grains of muriated pot-aſh are contained 10 grains of pot-aſh free from water and carbonic acid, there remain 4 grains of this laſt to be reckoned as conſtituent parts in 100 of lepidolite.

B.

a) *Two hundred and fifty* grains of powdered lepidolite were expoſed to a red-heat, during two hours, in a ſilver-crucible, previouſly mixed with the ſame quantity of very pure carbonated ſoda, that had effloreſced in the air. This mixture came out of the fire a compactly united maſs, of an uniform, lively brick-red. It was pulverized, and ſuperſaturated with dilute muriatic acid, and kept in digeſtion till the red colour had totally vaniſhed. The *ſiliceous earth* that ſubſided from this ſolution was afterwards ſeparated by means of the filter.

b) The muriatic ſolution was then evaporated to dryneſs; the ſaline maſs was extracted, by alkohol, in a low heat; the ſediment, left undiſſolved by this laſt, was rediſſolved in water, then combined with a little ammoniac, filtered, and again evaporated to a dry ſalt.

c) The dry ſalt, thus obtained, was again diſſolved in water, and, in combination with liquid acid of tartar, expoſed to a warm temperature. At the beginning, the mixture continued clear; but, gradually, it depoſited minute cryſtalline grains, which, after lixiviation and drying, weighed 12½ grains. They conſiſted of *regenerated tartar*, from which carbonated pot-aſh was produced by combuſtion.

d) I now returned to the precipitate, ſeparated by means of ammoniac (*b*). This I diſſolved in dilute ſulphuric acid; and, after having added to this ſolution the ſpirituous ſolution of the muriated alumine (*b*), as well as the muriatic ſolution from which the regenerated tartar had been ſeparated, I ſubjected the whole for ſome time to digeſtion; and finally freed it, by filtration, from the remaining browniſh, muddy depoſite. This ſolution, when farther evaporated, without any addition of acetated vegetable alkali, ſhot into regular cryſtals of alum, amounting to 185 grains. The remainder of it, ſtill farther evaporated, congealed to a ſhapeleſs ſaline maſs.

Thus, by the experiment B, the preſence of the alkaline ſaline conſtituent part in lepidolite has received an additional proof: for, theſe 250 grains of this foſſil yielded as much pot-aſh as was neceſſary to the production of the 12¼ grains of regenerated tartar, mentioned at (*c*), and likewiſe the quantity entering into the 185 grains of the cryſtallized alum here obtained.

However, the quantity of vegetable alkali naturally contained in lepidolite is more accurately ſhewn by the experiment A; according to which, as mentioned in its place (A. *d*), there muſt be added to its other conſtituent parts 4 *per cent.* of pot-aſh.

Hundred parts of *Lepidolite*, therefore, contain:

Silex	54,50
Alumine	38,25
Pot-aſh	4
Oxyds of manganeſe and *iron* . .	0,75
	97,50
Loſs, partly conſiſting of water .	2,50
	100

In my firſt analyſis I noticed my ſurpriſe, that, in this very fuſible ſtone, beſides the ſilex and alumine, no conſtituent part could be found to promote fuſion, except the very trifling portion of the oxyds of mangancſe and iron.

Yet I do not venture to affirm, unconditionally, that this fuſibility of *lepidolite* is owing to this alkaline ingredient now diſcovered in it; becauſe the *leucite*, whoſe earthy parts are likewiſe ſilex and alumine, as well as lepidolite, is, in fact, infuſible, notwithſtanding that it contains the alkaline ingredient in five times the quantity of that of lepidolite.

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LVII.

CHEMICAL EXAMINATION
OF
URANITE.

FIRST SECTION.*

1.) THE ancient philoſophers, who conſidered our globe as the center of the material univerſe; and the ſun, on the contrary, merely as a planet deſtined, like the others, to a periodical circumvolution round the earth, flattered themſelves that they had diſcovered a great myſtery of Nature, in the agreement of the *ſeven celeſtial bodies*, which they aſſumed for planets, with the *ſeven metals* known in thoſe times. In conſequence of the varions hypotheſes which they founded on this ſuppoſed myſtery, they allotted to each metal a certain planet, by whoſe aſtral effluvia its generation and maturation were to be promoted. In like manner, they took from theſe planets their names and ſymbols, to deſignate the metals ſubordinated to them. But as the above number of metals has long ſince been increaſed by later reſearches; and as the diſcovery of new planets has not kept pace with that of metals, the metals newly found out have been deprived of the honour of receiving their names from planets, like the older ores. They, therefore, muſt be ſatisfied with the name given them accidentally, and, in moſt inſtances, by the common miner.

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* Read in the Royal Academy of Sciences, at Berlin. See *Memoire Chimique et Mineralogique ſur l'Urane*, in the *Memoires de l'Academie Royal des Sciences*, &c. Août, 1786, juſqu'à la fin de 1787. Berlin, 1792.

Of late, *ſeventeen* metallic ſubſtances have been acknowledged as diſtinct metals, each of a nature peculiar to itſelf. The deſign of this eſſay is to add one to that number, the chemical properties of which will be explained in the ſequel*.

2.) The particular foſſil, by the decompoſition of which I have diſcovered this new metallic ſubſtance, is the black, or *pitch-blende* (*pſeudo-galena* of many) as it has been hitherto called. In the mean time, I ſhall continue to uſe that appellation, till, in the progreſs of this eſſay, the neceſſity of giving it a new name will be conſpicuous. This foſſil is found at *Joachimsthal* in Bohemia, and at *Johann Georgenſtadt*, in the metalliferous mountains of Saxony.

Only a few writers appear to have been formerly acquainted with this mineral. *Wallerius* and *Brünich* mention, indeed, under the head Argentiferous Ores of Zinc, the *pitch-blende*, and a black *pitch-ore* (*Pecherz*); but it does not appear that they meant by it, or even have known the above foſſil from *Joachimsthal* and *Johann-Georgenſtadt*. *Werner*, to whom its fracture, hardneſs, and gravity, ſufficiently indicated that it could not be a blende, has transferred it from the claſs of zinc-ores to that of the ores of iron, calling it *Eiſen-pecherz*; though only *ad interim*, until its proper place ſhould be aſcertained by chemical analyſis. A ſubſequent conjecture of his, that this foſſil might, perhaps, contain the metallic radical of *tungſten*, or *wolfram*, was thought to be ſupported by actual experiments made at

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* Even this number (17) of metallic ſubſtances has received an addition, by the *Titanium*, ſo lately diſcovered, as is ſhewn by *Eſſay* XIV. pages 200 and 210.

Schemnitz[*]. But this pretended fact is contradicted by the reſult of the following examination.

3.) The varieties of this foſſil, that have hitherto occurred, may be divided into two ſorts. The *firſt* of them is found in browniſh-black, maſſive, and, for the moſt part, outwardly flat, reniform pieces. It is reſplendent both externally and internally; wholly opake, and of an imperfect conchoidal fracture. It is brittle, admits of being eaſily comminuted by trituration, and affords then a black powder, tending to the greeniſh. Its ſpecific gravity, upon an average, is 7,500.

To this ſort belong, in particular, the pitch-blendes dug at *Joachimsthal*, in the mines, or galleries; *Sächsischer Edelleutstolln, and Hohe Tanne*; where they are accompanied by brown-red ponderous ſpar.

The *ſecond variety*, to which belongs the greateſt part of pitch-blende that occurs at *Johann-Georgenstadt*, is greyiſh black, and exhibits various degradations, from the glittering to the dull or dim. At that place it is obtained in the mine *Georg Wagſfort*, in larger or ſmaller maſſes, between ſtrata of ſchiſtoſe mica (*Glimmerſchiefer*); which is nearly in a ſtate of decay. It is uſually accompanied by a metallic earth (oxyd), of a yellow, reddiſh, and light-brown colour; and, beſides, alſo frequently by the *green mica*, as it is called, cryſtallized in ſmall quadrangular tables. Sometimes it is obſerved to be inveſted by compact galena (*Bleyſchweif*), or having this latter diſſeminated in its ſubſtance in delicate veins and points. It has alſo been met with there in the mine *Neujahrsmaaſſen*, between alternate ſtrata of the fibrous brown iron-ſtone[†].

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[*] See *Bergmannisches Journal*. 1789. Vol. I. page 612.

[†] A more ample deſcription of its external properties has been given by *Karſten*, in the 4th vol. of the *Beobacht. u. Entdeck. a. d. Naturkunde*. Berlin, 1792, page 178.

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4.) When pitch-blende is tried by itſelf, before the blow-pipe, it undergoes no alteration, and is perfectly infuſible. If mixed with ſoda, or borax, and placed in the ſame ſituation, it is converted into a grey, cloudy button, reſembling ſcoriæ. But with a neutral phoſphat it produces a clear, green globule. If in theſe trials ſome minute metallic grains ever appear, they proceed from the lead interſperſed in the foſſil.

5. *a*) I expoſed *half an ounce* of triturated pitch-blende to a ſtrong red-heat, in a coated glaſs-retort. After cooling, I found that it had loſt ſeven grains. A ſmall portion of ſulphuric acid has alſo paſſed over, and in the neck of the retort a little ſulphur was obſerved to be ſublimed.

b) Another equal quantity of pitch-blende was roaſted in open fire, that is, on a teſt under the muffle, until all its ſulphur had volatilized. By this management it loſt 20 grains. Upon this I kept it one hour longer in ignition, and obſerved that its weight had again increaſed eight grains.

6.) To examine the relations of pitch-blende to the *fixed alkalis* in the *dry way*, I triturated ½ ounce of it with one ounce of carbonated pot-aſh, and urged the fire to the fuſion of the mixture in the crucible. The maſs poured out of the veſſel was black-grey, compact, hard, and of a lamellar fracture. When ground, boiled with water, and filtered, the powder of the foſſil remained on the paper with its former black colour, and alſo nearly with its original weight. The colourleſs fluid had merely an alkaline taſte, excepting only a ſlight indication of alkaline ſulphuret (*liver of ſulphur*); and when ſaturated with nitric acid, it depoſited ſome flocculi of ſiliceous earth, weighing four grains.

By this inſolubility of pitch-blende, in melting pot-aſh, it was decided that it in no way belonged to the foſſils which contain tungſten, of wolfram.

7.) I now proceeded to examine its habitudes with *acids.*

Dilute ſulphuric acid was incapable of effecting a true ſolution; it only extracted from it a faint greeniſh tincture. Even *concentrated ſulphuric acid* did not entirely diſſolve this foſſil: for, after $\frac{1}{2}$ ounce of pitch-blende had been digeſted with one ounce of that acid, in a retort, the liquor being then again diſtilled off to dryneſs, and the reſidue ſoftened with water, and filtered, its undiſſolved part ſtill weighed three drachms: and likewiſe the black colour which it ſtill preſerved ſhewed that no perfect ſolution had taken place. The fluid that had paſſed over was ſulphureous acid; and the ſolution filtered off from the reſidue had a green colour.

8). *Nitric acid*, on the contrary, produced a more complete decompoſition of that foſſil.

a) *Half an ounce* of the greyiſh-black, dull pitch-blende was digeſted, in a low-heat, with moderately ſtrong nitric acid. It was attacked by the acid with an evolution of red nitrous vapours. I affuſed, by degrees, more of the acid, till the diſappearance of the black colour of the foſſil ſhewed that its decompoſition was accompliſhed. The ſolution, when again diluted with water, was of a bright wine-yellow, variegated with the greeniſh. It left on the paper a white-grey reſidue, weighing 16 grains upon deſiccation. This took fire, when heated in an earthen pot, and burned with a ſulphureous flame; loſing thereby $5\frac{1}{2}$ grains. The remaining $10\frac{1}{2}$ grains conſiſted of ſilex; from which nitro-muriatic acid ſtill extracted ſome portion of iron.

b) One *half ounce* of the *blacker ſort* of pitch-blende, treated in the ſame manner with nitric acid, coagulated, upon ſolution, to a bright-green gelatinous conſiſtence, in which ſome light grey-yellow particles lay diſperſed. By dilution with water, and filtration, it left 26 grains of a reddiſh-grey reſidue, 6 grains of which were ſulphur, and the remainder an earthy matter, impregnated with iron.

c) When no pure, compact lumps can be had, the pitch-blende, which is ſtill embodied with its matrix, may alſo be employed for extraction with nitric acid. *Twenty-four* ounces of moderately ſtrong nitric acid, affuſed upon 8 ounces of fragments of this impure pitch-blende, previouſly pulverized, attacked it with vehemence; the mixture became hot, and emitted red vapours. After digeſtion for ſome time, I diluted the ſolution with water, and filtered it. The *gangue*, or matrix of the ſhiſtoſe mica kind, exiſting in the foſſil, remained behind as a light-brown mud; which, after waſhing and deſiccation, weighed 4½ ounces, but loſt one drachm more by burning off the ſulphur which it contained. I concentrated the greeniſh-yellow ſolution, by diſtillation, from a retort; by which management nitrat of lead ſeparated, in white glanular cryſtals, amounting to 50 grains.

g) By *muriatic acid* only an incomplete ſolution was produced.

But, if this acid be mixed with one third part of the nitric, the *nitro-muriatic acid* ariſing from this combination effects a perfect ſolution.

Half an ounce of pitch-blende, mixed with two ounces of aqua regia, became hot, and was violently attacked by this ſolvent; at the ſame time that the mixture ſtrongly efferveſced, and the ſolution was almoſt entirely effected for the greateſt part. When it had digeſted a while, it was diluted with water, and paſſed through the filter. Its reſidue weighed 13 grains; which, after the combuſtion of the ſulphur, left nine grains of a ſiliceous matrix. The ſolution depoſited muriat of lead, while cooling, in minute, white, needle-ſhaped cryſtals, which, by reduction, yielded a reguline bead of lead, of ½ grain. After ſome time, there appeared in the ſolution ſome beautiful, large, bright, greeniſh-yellow cryſtals, in rhomboidal ſix-ſided tables.

10.) Endeavouring to become more accurately acquainted with the metallic principle which is the chief ingredient in pitch-blende, as well as with its chemical relations to other ſubſtances, I performed various experiments with the nitric and nitro-muriatic ſolutions before mentioned.

At firſt I attempted to find whether a *reduction* of it would take place in the *humid way*. With this view, I filled two glaſſes with thoſe ſolutions, immerſing in the one ſome poliſhed iron, and in the other a thin ſtick of zinc. But in neither caſe was any thing precipitated.

11.) Pruſſiat of pot-aſh threw down, from both theſe ſolutions, a *deep-brown-red* precipitate, reſembling red ſulphurated oxyd of antimony (*Kerme's mineral.*). This phenomenon is one of the moſt characteriſtic properties, by which this metallic ſubſtance is diſtinguiſhed. It is true, copper likewiſe falls down, of a brown colour, if precipitated from acid menſtrua by means of Pruſſian alkali; but then it appears rather more in the form of flocculi, of a woolly coheſion: whereas the former, on its precipitation, directly ſpreads, or diffuſes itſelf through the whole volume of the fluid. Still more does the brown-red precipitate, obtained by precipitating the oxyd of molybdena from its muriatic ſolution, by means of Pruſſian alkali, reſemble that mentioned above. However, beſides that the colour of this laſt is brighter, theſe two metallic ſubſtances are, in every other reſpect, ſo different, that they cannot eaſily be miſtaken for each other.

If the pitch-blende, as is moſtly the caſe, be accidentally accompanied by a portion of iron, the precipitate appears, at firſt, of a dirty black, but, after the ſeparation of this, its colour is a purer brown.

12.) *Sulphuret of ammoniac* precipitates the metallic ſubſtance of pitch-blende, diſſolved in acids, of a *brown-yellow* colour; in which caſe, the mixture is uſually covered by a white-grey pellicle of a metallic luſtre.

13.) By *tincture of galls*, or gallic acid, added to exceſs, only a ſlight quantity of a blackiſh precipitate is produced. But if the predominant part of the acid be neutralized by an alkali, a copious precipitation of a *chocolate-brown* enſues.

14.) All *alkalis* throw down the metallic portion from the acid ſolutions of pitch-blende, of a *yellow colour*. This affords another character peculiar to that metallic ſubſtance. The ſhades, or degradations of that yellow colour, are various, according to the degrees of purity of the foſſil, and, likewiſe, according to the nature of the alkaline ſalt employed in the proceſs.

The fixed alkalis promote the precipitation, in the moſt complete manner, if they are uſed in their cauſtic, or pure ſtate. The precipitate is then commonly lemon-yellow; but it inclines more to the white, if carbonated alkali is employed as a precipitant.

15.) If more carbonated alkali be added than is required to ſaturate the acid, part of the metallic oxyd will be rediſſolved; but it falls again down, of a lemon-yellow, by ſaturating the exceſſive portion of the alkali. A ſimilar re-diſſolution, in carbonated fixed alkali, happens, when the yellow oxyd, recently precipitated and waſhed, while yet moiſt, is mixed with deliqueſced pot-aſh, and digeſted in a boiling heat. If, to the ſaffron-yellow ſolution, after ſeparation of the undiſſolved reſidue, nitric acid is added, it throws down the diſſolved part of a pale yellow colour.

On repeating this experiment with cauſtic lixivium, the colour of the metallic oxyd changed to a dark-brown. But this lixivium, being afterwards examined, was found to contain nothing of that oxyd. This circumſtance ſerves to prove that it is not the alkali, but the carbonic acid combined with it, that contributes to effect the ſolution before noticed.

16.) Somewhat different was the colour of the precipitate which I have obtained from the greeniſh nitric ſolution of the blacker variety of pitch-blende (8. *b.*), by means of cauſtic ſoda; for this inclined from the yellow to the green. This is not owing to a latent portion of copper in the foſſil; as the precipitate gives neither colour nor taſte to cauſtic ammoniac poured upon it.

17.) This yellow metallic oxyd readily diſſolves in acids.

When treated with dilute *ſulphuric acid*, gently warmed, it was ſoon diſſolved, leaving only the portion of lead which ſtill remained in it. The ſolution, duly evaporated, afforded a lemon-yellow metallic ſulphat, cryſtallized in ſmall accumulated columns.

18.) The ſolution of the yellow metallic oxyd in weakened *nitric acid*, and made to cryſtallize by evaporation, at firſt depoſited a ſmall quantity of nitrat of lead, and, afterwards, beautiful, clear, oblong, hexagonal tables, of a pleaſing, light-greeniſh colour; ſome of which were ¾ of an inch long, and ½ of an inch broad. To preſerve theſe cryſtals in their original perfection, they muſt be kept in a cloſed veſſel, as they ſeem liable to ſome decay by the acceſs of air.

19.) The ſolution of this metallic oxyd, prepared by *muriatic acid*, evaporated to the point of cryſtallization, and left ſtanding in the cold, at firſt yielded ſome muriated lead, in fine needles; but, after this, it ſhot into yellowiſh-green cryſtals, the fundamental figure of which appears to be the rhomboidal, or oblique-quadrangular table.

20.) By diſtilled *vinegar*, ſtrengthened by freezing, this metallic calx was diſſolved, with the aid of digeſtion. After gentle evaporation, this ſolution afforded fine, clear, topaz-yellow cryſtals, in regular, four-ſided, thin columns, with tetrahedral pointed terminations, ſome of them one inch long. When I ſubjected ſome of theſe cryſtals to ignition, beginning with a low heat, the metallic oxyd left, after the expulſion of the acetic acid, preſerved the ſame figure, for the moſt part, which the cryſtals had originally poſſeſſed.

21.) *Phoſphoric acid*, likewiſe, is a ſolvent of the precipitate obtained from pitch-blende. But this ſolution does not long continue clear; the phoſphated metallic oxyd falling down, by degrees, in yellow-white, amorphous flocculi, of difficult ſolution in water. A ſimilar precipitate alſo ariſes on pouring phoſphoric acid into the acetic ſolution of this foſſil.

22.) I introduced a mixture of one part of pitch-blende with three of nitre, by ſucceſſive portions, into a red-hot crucible. The maſs foamed much; but only a weak detonation was obſervable. I kept it in ignition for half an hour, after which I ſet it aſide to cool. It was of a chocolate-brown; and when this maſs, liquified with water, had been filtered, the powder of the foſſil left on the paper remained of the ſame colour. The colourleſs lixivium contained ſtill ſome undecompoſed nitre; and acids cauſed it to depoſite a whitiſh precipitate, which for the moſt part conſiſted of ſilex.

23.) After theſe reſearches, I made ſome experiments relative to the proceſs of *reduction.*—When the yellow metallic oxyd was tried upon charcoal before the blow-pipe, it exhibited the ſame phenomena as were mentioned of the crude pitch-blende, (4.); excepting that it acquired a browniſh-grey colour by ignition; and that the browniſh colour of the globule produced, on its treatment with ſoda and borax, was purer and clearer than that from the rough foſſil: in the ſame manner as the colour of the green globule ariſing from its mixture with an alkaline phoſphat, in the like proceſs, was more pure and clear.

24.) The trials made by fuſion in the crucible gave all exactly ſuch reſults, as thoſe previous ſmall trials upon charcoal would allow me to expect.

a) *One* drachm of *rough pitch-blende*, mixed with 1½ drachm of calcined borax, together with ſome charcoal-duſt, and covered with muriat of ſoda; and

b) An equal quantity of rough pitch-blende, mingled with two parts of black flux, and a little muriat of ſoda, where melted, each ſeparately, in the wind-furnace with a ſtrong fire. In both caſes the foſſil was converted into a black-grey, dim ſcoria, without any trace of reduction: only that ſome metallic grains of lead appeared, originating from the particles of that metal diſſeminated in the rough foſſil.

25.) In the following experiments I employed the *pure yellow precipitate* before mentioned.

a) *One* drachm of it was mixed with two drachms of black flux, and inſerted in a charcoal-crucible;

b) Another drachm was mingled with twice its weight of calcined borax, and likewiſe put in a crucible made of charcoal; and

c) A third drachm was mixed with 10 grains of charcoal-duſt, 20 grains of calcined borax, and two drachms of powdered white glaſs.

Theſe mixtures, the crucibles being firſt luted, were expoſed for one hour and a half to the ſtrongeſt heat of the melting furnace.

The product, which in all three crucibles was nearly the ſame, conſiſted of a black vitreous ſcoria, but exhibited no indication of any metallic button.

26.) Being thus convinced, that the reduction of this metallic oxyd, which I had in view, was not to be accompliſhed by means of ſaline and vitrifying ſubſtances, I reſolved to treat it merely with combuſtible bodies, after the manner of the aſſays of mangaueſe. For this purpoſe, I triturated 120 grains of the yellow metallic oxyd to a paſte, with linſeed-oil, and cauſed the oil gently to burn on a teſt. There remained 85 grains of a heavy black powder behind; which I expoſed, in a well ſecured charcoal-crucible, to the medium heat of the procelain-furnace.

At the ſame time, another crucible, containing pure oxyd of *manganeſe*, and prepared in the ſame manner, was expoſed to the ſame fire.

When both theſe crucibles were brought back from the furnace, I found, that, in the *ſecond*, the reduction of manganeſe to the reguline, or metallic ſtate, had been moſt perfectly accompliſhed. But in the *firſt* crucible I found the oxyd, obtained from pitch-blende, in the form of a heavy and only looſely coherent maſs; which by friction between the fingers could be divided into a fine black-brown duſt, yet poſſeſſed of a metallic luſtre.

In pouring nitric acid upon a part of that duſt, the ſolution went on with pretty conſiderable energy; the mixture growing hot, and giving out a quantity of red nitrous fumes. By this phenomenon, I was perſuaded, that the oxyd had in ſome manner been revived to the metallic ſtate, although not run into one maſs; and, hence, that this metallic ſubſtance is more refractory than even manganeſe.

27.) To experience, whether this oxyd of pitch-blende, thus far metallized, would not perhaps prove more fuſible, I put the remaining portion in a charcoal-crucible; covering it with half its quantity of calcined borax, and the remaining ſpace of the veſſel with pulverized charcoal. The outer crucible of baked clay, into which the former was inſerted, was then well luted, and expoſed to the ſtrongeſt heat of the porcelain-furnace. My expectation, as I found by the reſult, was not totally diſappointed; for I now obtained a coherent maſs, conſiſting of conglutinated extremely minute metallic grains, whoſe aggregation, however, was not compact, but finely porous, and like froth. The colour of that metallic maſs was outwardly dark-grey, but inclining on the ſtreak to the browniſh. Its metallic luſtre, for want of perfect denſity, was but moderate, and the coheſion of its integrant particles only ſlight. Its ſpecific gravity, 6,440.

No alteration was produced, when ſmall portions of that regulus were ignited upon charcoal with the aſſiſtance of the blow-pipe. On fuſing it with fuſible phoſphoric ſalt, the globule, while melting, was coated with a dull, ſilvery white pellicle, formed by cohering, exceedingly fine metallic globules. On continuing the fuſion, this metallic cruſt entered deeply into the body of the globule, which at laſt acquired the appearance of a dim, grey-green, porous ſcoria.

28.) With the view of attempting an artificial mineralization by ſulphur, I mixed the yellow oxyd with twice its weight of ſulphur in a ſmall glaſs-retort, and expelled again from it the greateſt part of the ſulphur, by applying heat. The reſidue combined with the reſt of the ſulphur was a black-brown, compact maſs. But the degree of affinity of this metallic ſubſtance with ſulphur is but low; for, on expoſing again this ſulphurated maſs, in another retort, to the action of fire, the remainder of the ſulphur admitted of being entirely driven out; while the metallic part remained behind in the form of a black, heavy, granular powder.

29.) To inveſtigate what colour this metallic oxyd would give to glaſs-frits, and what effect it would produce on porcelain, when applied to it as an enamel colour, the following experiments were made.

a)

a) *Silex*	2 drachms,
Mild *pot-aſh*	1 drachm,
Yellow metallic oxyd	10 grains,

produced a clear, light-brown glaſs.

b) *Silex*	2 drachms,
Mild *ſoda*	1 drachm,
Yellow metallic oxyd	10 grains,

yielded an opake, black-grey glaſs.

c) *Silex*, Burnt *borax*, of each	2 drachms,
Yellow metallic oxyd	20 grains,

afforded a glaſs perfectly reſembling brown rock-cryſtal (*Rauch-topaz*).

d) *Silex*, *Vitreous phoſphoric acid*, prepared from bones,	2 drachms of each,
Yellow metallic oxyd	20 grains,

gave a bright apple-green, opake glaſs, almoſt like chryſopraſe.

e) *Vitreous phoſphoric acid*, from animal bones	2 drachms,
Yellow metallic oxyd	10 grains,

produced a clear emerald green glaſs.

Theſe two laſt vitrifications, by degrees, attracted moiſture from the atmoſphere.

f) The *yellow metallic oxyd*, gently ignited, mixed with a proper flux, and applied to porcelain, and fuſed upon it in the enamelling furnace, produced a ſaturated or deep orange-yellow colour.

30.) From the whole of theſe experiments it is manifeſt, that the pitch-blende does not belong either to the ores of zinc, or to thoſe of iron, nor yet to the genus of tungſten or wolfram, and in general to none of the metallic ſubſtances hitherto known; but, on the contrary, that it conſiſts of a *peculiar*, *diſtinct*, *metallic ſubſtance.* Therefore its former denominations, *pitch-blende*, *pitch-iron-ore*, &c. are no longer applicable, and muſt be ſupplied by another more appropriate name.—I have choſen that of *uranite*, *(Uranium)*, as a kind of memorial, that the chemical diſcovery of this new metal happened in the period of the aſtronomical diſcovery of the new planet *Uranus**.

31.) In the pit *Georg Wagsfort*, *at Johann-Georgenſtadt*, the *metal uranium* likewiſe occurs in the form of a metallic oxyd, of an earthy appearance. This is the earthy foſſil, already mentioned at the beginning of this eſſay, which there accompanies the compact uranitic ore under various ſhades of colour, paſſing from the pale ſulphur-yellow into the brick-red, as alſo into the brown-yellow. The light-yellow and reddiſh varieties are the pureſt; ſince, when diſſolved in nitric acid, and treated with Pruſſian alkali, they immediately precipitate of a brown-red colour. The darker varieties, on the other hand, contain more or leſs of iron. This earthy oxyd of uranium has formerly been taken for an ochre of iron. It has likewiſe been conſidered, as the product ariſing from a previous decay of ſhiſtoſe mica, which forms the gangue, containing this foſſil in the mine juſt mentioned.

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* This is called *Georgium ſidus* in England only.—Tranſl.

32.) To this place likewiſe belongs the *green mica*, as it was formerly called, that is alſo dug from the ſame pit. This beautiful foſſil is found in the fiſſures, rifts, and partings of the rock, as well as upon the earthy uranitic oxyd; for the moſt part, in the form of thin quadrilateral tables, ſome of which approach to the cubical figure. Its colour is variable, paſſing from the emerald green to that of the green-finch, to a lemon-yellow, and even to the ſilver-white.—It is alſo found on the *Tannenbaum* at *Eibenſtock*, moſtly upon brown hornſtone-quarz, though but very ſparingly.

33.) It is indeed certain, upon various grounds, that this foſſil is not a true mica. Yet its nature continued to be a matter of queſtion, until *Bergmann*, on analyſing it, thought that he had diſcovered in it muriated copper and argil; and it was upon this authority that *Werner* has given it the name *Chalcolite*. Notwithſtanding this, *Bergmann* ſtill entertained ſome doubt concerning the reſult of his own experiments; eſpecially as he could examine only a very ſmall quantity of it.

34.) But according to my experiments, this green mica, or chalcolite, is a *crystallized oxyd of uranium, coloured by copper*. After having procured, with great trouble, and ſacrificing ſeveral ſpecimens, a ſmall quantity of exquiſitely pure cryſtals, I poured upon them nitric acid, which diſſolved them quietly, and entirely in the cold. Into one part of this ſolution I dropped nitrated ſilver; but no turbidneſs enſued, though *Bergmann* aſſerts that he has obtained muriat of ſilver. (Horn-ſilver).

Into another portion of the ſolution of the green cryſtals I introduced a poliſhed ſteel-ſpring, and found that it became incruſted with a coppery coating of metallic luſtre.

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The remainder of that ſolution was ſaturated with cauſtic ammoniac. A blueiſh-grey precipitate fell down, and the liquor, likewiſe, aſſumed a blue colour. I then added as much ammoniac, as was neceſſary to diſſolve all the copper contained in that fluid; after which, I decanted the bright blue ſolution from the precipitate: affuſing upon this laſt ſucceſſive freſh portions of ammoniac, until this alkaline fluid was no longer tinged blue. The reſidue, which had been thus freed from copper, I re-diſſolved in nitric acid, dividing the ſolution into three parts. When a poliſhed watch-ſpring had been immerſed in the *firſt*, neither copper, nor any thing elſe was precipitated. By combining the *ſecond* portion with Pruſſian alkali, a brown-red precipitate ſufficiently copious was obtained. From the *third* portion, cauſtic pot-aſh threw down a pure yellow oxyd of uranium.

Copper, however, ſhould not be conſidered as an eſſential conſtituent part of the cryſtallized oxyd of uranium; ſince I have not found the leaſt trace of it in another variety, that had a pure wax-yellow colour.

SECOND SECTION.

ANOTHER more pure variety of compact uranite, of a luſtre almoſt metallic, which I afterwards received from *Joachimsthal*, induced me to repeat its analyſis.

A.

a) *Five hundred* grains of this uranitic ore were powdered, and digeſted in a gentle heat, with nitric acid of a moderate ſtrength. The quantity of the acid employed, not being ſufficient to effect a total ſolution, the mixture appeared like a fluid, rendered turbid by a fine brick-red mud; but which diſappeared on the addition of another ſmall portion of nitric acid. The ſolution became clear, while a light-grey flocculent matter ſeparated, and was of a greeniſh aſpect. The reſidue collected by filtering weighed

30 grains after drying. When placed upon a teſt, gently heated, its *ſulphureous* part was conſumed with a faint flame; and the remainder proved upon trial to be mere *ſiliceous earth*, weighing 25 grains.

b) The nitric ſolution was in part generally evaporated. It depoſited nitrat of lead; which, when re-diſſolved in water, and combined with ſulphuric acid, yielded 35 grains of ſulphated lead. Theſe indicate almoſt exactly 25 grains of *metallic lead*.

After this ſeparation of the lead, the nitric ſolution gradually ſhot into longiſh hexahedral plates of a light-yellow colour, ſomewhat inclining to the green. This nitrat of uranium, re-diſſolved in water, and treated with cauſtic pot-aſh, afforded 440 grains of yellow precipitate.

c) The remainder of the ſolution, that would no longer cryſtallize, when tried by Pruſſian alkali, ſhewed by the blue colour of its precipitate, that it had been contaminated with iron. This precipitate was then inpiſſated, driving out the nitric acid by means of heat; after which it left a reſidue weighing 40 grains. This laſt, when boiled again with nitric acid, and filtered, left on the paper a red *oxyd of iron*; which, triturated with linſeed-oil, and ignited, obeyed the magnet, and weighed 13 grains.

Since, therefore, an *hundred* parts of this ore contain no more than *one* part of *ſulphur*, and, on the other hand, *five* parts of *lead*; there remains no doubt, but that this ſmall quantity of ſulphur belongs to the lead exiſting in the ore. For this reaſon, I no longer conſider the black uranitic ore, including its varieties, and taken by itſelf, as an *ore mineralized by ſulphur*, but as an *imperfect metallic oxyd*; that is to ſay, combined with but little oxygen. This condition, ſo nearly approaching the metallic ſtate, is the cauſe why the ſolution of this oxyd in nitric acid is attended with extrication of heat and nitrous vapours.

Hence, according to what has been ſaid, the ſhining black *ore of uranium* from *Joachimſthal* is compoſed, in *one hundred* parts, of:

Sulphat of lead	6
Silex	5
Oxyd of iron, attractible by the magnet	2,50
URANIUM	86,50
	100

B.

With the yellow oxyd, that had been precipitated from the ſolution of the uranitic nitrat, freed from iron, (A. 6.) I inſtituted ſeveral experiments, with a view of its *reduction*. Theſe, however, did not completely anſwer my deſire, to obtain a pure metallic button, run into a compact maſs. Of thoſe experiments, the following is that which has beſt ſucceeded.

Fifty grains of this oxyd, when ignited, were formed with wax into a ball, and in a well-cloſed charcoal crucible expoſed to the moſt vehement heat of the porcelain-furnace, the intenſity of which gave 170 degrees in *Wedgwood's pyrometer*. The metallic button obtained weighed 28 grains, and preſented a dark-grey, hard, firmly cohering, finely-grained, of very minute pores, and, outwardly, glittering maſs. On raſping this with the file, or rubbing it with another hard body, the metallic luſtre appeared on the place, thus laid bare, of an iron-grey colour; whereas in the other aſſays that were leſs perfect, the ſtreak of the uranitic regulus is uſually more verging to the browniſh. This metallic button likewiſe ſurpaſſed in ſpecific gravity thoſe before obtained; being, 8,100.

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LVIII.

CHEMICAL EXAMINATION

OF TWO NEWLY DISCOVERED

TITANITES.

THE diſcovery of *Titanium*, in the red Hungarian ſhörl*, and in the ſmall hair-brown cryſtals, from the country about *Paſſau*†, having ſo much excited the attention of Chemiſts and Mineralogiſts, it was natural to expect, that this new metallic ſubſtance would alſo be found in other places. The event has ſhewn, that this expectation was not ill founded.

The chemical analyſis made at *Paris* by *Vauquelin* and *Hècht*, with a foſſil, diſcovered by *Miché* and *Cordier* at *St. Yrieux*, in the department of *Haute-Vienne*, has ſhewn, that this metallic ſubſtance is likewiſe a native of France‡.

To this the preſent eſſay affords a new addition, by giving the analyſis of two other *titanites*, but lately diſcovered.

FIRST SECTION.

Titanite from Spain.

I HAD the pleaſure of receiving from the collection of *Baron Racknitz* at *Dreſden*, which is particularly rich in

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* See *Eſſay* XIV. page 200.

† *Eſſay* XV. page 211.

‡ *Journal des Mines*. Paris. No. XV. page 10.

Spaniſh minerals, a foſſil whoſe outward characters juſtified the ſuſpicion, that it might be an ore of Titanium.

It occurs at *Cajuelo*, near *Vuitrago*, in the province of *Burgos*.

The internal colour of it is a light reddiſh-brown, inclining in ſome places to the copper-red; but externally it is coated with white clay. It ſeems to have the form of a hexahedral column, with a flat ſix-ſided pyramidal termination; but inſtead of the actual point, it has a regular excavation, which reſembles an inverted, hollowed, hexahedral pyramid. In the inſide, that foſſil has a ſtrong ſemi-metallic luſtre. Its croſs-fracture is very diſtinctly ſtraight lamellar; and its longitudinal fracture imperfectly and ſmall conchoidal. It is very little tranſparent on the edges; brittle, very hard, and of difficult levigation, by which it affords a greyiſh-brown powder. The ſpecific gravity of it is = 4,180.

One *hundred* grains of it, finely ground, and mingled with 600 grains of mild pot-aſh, were brought to fuſion in a crucible. The melted maſs was of a pearly-grey, which, upon re-diſſolution in hot water, depoſited the *oxyd of titanium* of a perfectly white colour. When this had been filtered off from the colourleſs alkaline fluid, and lixiviated with water, till the waſhings no farther indicated any trace of alkali, it was deſiccated, and found to weigh 175 grains.

This titanic oxyd readily diſſolved in muriatic acid, and was precipitated from it of a permanent green, by Pruſſian alkali, and of a lively brown-red, by gallic acid; and in general, in all its other properties, it agreed with the white oxyd of titanium, extracted from the red Hungarian ſhörl.

SECOND SECTION.

Titanite from Aſchaffenburg.

WITH the foregoing titanite from Spain another foſſil correſponds, which Prince *Dimitri Gallitzin* has found ſeveral years paſt not far from *Aſchaffenburg*, in the *Speſsart* foreſt, preſerved in his collection as a mineral not yet aſcertained.

Its interior colour is a deep reddiſh-brown; externally it paſſes ſomewhat into the lead-grey, and exhibits ſilver-white ſcales of mica adhering to it. The ſpecimen, here examined, was a rounded priſmatic, and, as it appeared, a four-ſided cryſtal; the alternate angles of whoſe facets ſeemed to be obtuſe, and the ends apparently not yet completely cryſtallized. Its fracture exhibits a ſtrong ſemi-metallic ſplendour. The longitudinal fracture is ſtraight foliated; the croſs fracture, imperfectly conchoidal. It is untranſparent, brittle, and very hard. Its ſpecific gravity was found to be 4,055.

One hundred grains of this titanite were finely powdered, and fuſed with 600 grains of carbonated pot-aſh. The maſs, when fixed by cooling, preſented a greeniſh ſurface, and a pearly grey fracture. Upon pulverization, and ſolution in water, the filtered alkaline liquor was likewiſe greeniſh, but ſoon loſt its colour. The lixiviated and dried *oxyd of titanium* weighed 166 grains. Its white colour had a little of a reddiſh tinge, ariſing, perhaps, from a ſmall portion of mangaueſe; the traces of which were ſhewn by the external greeniſh colour of the melted maſs, as well as afterwards by that of the alkaline liquor.

As for the reſt, the metallic oxyd obtained from this foſſil of *Aſchaffenburg* exhibited in every reſpect the ſame habitudes or relations, as the preceding from *Spain*, or that which had been ſeparated from the *Hungarian* titanite.

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LIX.

CHEMICAL EXAMINATION

OF SOME

FERRUGINOUS TITANITES.

FIRST SECTION.

Iron-ſhot Titanite from Cornwall.

WITHIN a few years a foſſil has been brought into notice by the name *Menachanite*, which has been found in the pariſh of *Menachan*, in *Cornwall*, and conſiſts of grey-black, ſand-like grains, obeying the magnet. Mr. *M^cGregor*, of Menachan, who dedicates his ſtudy to mineralogical chemiſtry, has given not only the firſt information of this foſſil, but alſo a full narrative of his chemical reſearches concerning it. The chief reſult of theſe is, that menachanite has for its conſtituent parts iron, and a peculiar *metallic oxyd of an unknown nature**.

By the following examination it will appear, that this ſubſtance, which, beſides iron, forms the ſecond chief component principle of menachanite, is preciſely the very ſame which conſtitutes the Hungarian red ſhörl; namely, *oxyd of titanium*. With this opinion alſo, moſt of the phenomena, noted down by *M^c Gregor*, in his operations with menachanite, agree.

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* *Crell's Chemiſche Annalen*. 1791. vol. I. pages 40 and 103.

Though I was eaſily convinced of this fact by my own experiments, it ſeemed, on the other hand, very difficult to ſeparate entirely the iron from the titanic oxyd; and, hence, to aſcertain the true proportion of theſe two ingredients to each other. Paſſing over various experiments which I made with this deſign, I will relate only the two following, by which I obtained the oxyd of titanium, freed the moſt from iron.

A.

a) *Two hundred* grains of menachanite, finely powdered, were mixed with ten times their quantity of a lixivium, compoſed of equal parts of cauſtic pot-aſh and water. This mixture, being inpiſſated to dryneſs in a poliſhed iron-pot, lodged in a ſand-bath, was afterwards ignited in open fire. The maſs ran into thick fuſion, and aſſumed in cooling a dirty dark-green colour.

b) By dilution with water, it gave a greeniſh ſolution, from which a dark cinnamon-brown powder ſubſided, which, detained on the filter, edulcorated, and dried, appeared very looſe, and weighed 374 grains.

c) The green alkaline fluid ſoon loſt its colour, and depoſited ſome brown flakes, which upon trial were found to be an impure *oxyd of mangane ſe*, and weighed half a grain. When this liquor had been treated with an over-proportion of muriatic acid, and again neutralized with carbonated potaſh, it afforded a whitiſh precipitate, which afterwards was decompoſed into ſeven grains of ignited *ſilex*, and two grains of *oxyd of titanium.*

d) The 374 grains of brown-powder (*b*) were mixed with ſix ounces of muriat of ammoniac, and ſublimed in a retort.

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retort. The ſal-ammoniac volatilized of a ſtrong yellow. The reſidue had the form of a looſe, iſabella-yellow powder, and was found to be ſtill contaminated with iron. When freed from this metal by previous lixiviation with water, and ſubſequent digeſtion with muriatic acid, it was of a grey-white, after a repeated waſhing and drying, and amounted to 168 grains.

e) This grey-white metallic oxyd, proving inſoluble in acids, was fuſed in a crucible with five times its quantity of carbonated pot-aſh, and poured out. After congelation, the ſaline maſs preſented a pearly white; was compact, and of a coarſe-ſtriated fracture. On triturating, and waſhing it with water, the metallic oxyd was left behind of a perfectly white colour. This, when edulcorated and dried, weighed 276 grains, and ſhewed itſelf in every reſpect to be a completely pure *oxyd of titanium.*

f) To obtain the iron, I diſſolved in water the ſublimed muriat of ammoniac *(d)*, mixed the ſolution with the water employed for edulcorating the reſidue, which thereby became muriated, and then I ſaturated the whole with cauſtic ammoniac. The brown *oxyd of iron*, thus ſeparated, was dried, drenched with linſeed-oil, and heated to redneſs. It weighed 100 grains, and was rapidly and entirely attracted by the magnet.

B.

I effected another complete decompoſition of menachanite in the following ſhorter way.

a) *Two hundred* grains of menachanite were prepared for their decompoſition in the ſame manner as explained before at *(*A. *a*, and *b)*; and the light-brown powder, thus obtained, was ignited for half an hour in a crucible. It now received a blackiſh chocolate-brown colour, and weighed 260 grains.

b) After having affuſed upon it three ounces of muriatic acid, I evaporated it in a porcelain veſſel to a moderately deſiccated maſs; the colour of which was yellow, like the yolk of eggs, and mixed with orange-yellow. It was then diluted with water, and put on the filter. The filtered liquor contained muriated iron, and the waſhed reſidue exhibited on the paper a fine, heavy powder, of an iſabella-yellow, which, dried in a low-heat, weighed 106 grains.

c) I mixed this with a quintuple portion of carbonated pot-aſh, and brought it into fuſion in a crucible. The maſs, when poured out, and fixed by refrigeration, was of a pearl-grey, with ſome light-browniſh ſpots. Upon triturating, and edulcorating it with water, the titanic oxyd remained behind as a flocculent, yellowiſh-white powder, amounting to 226 grains, when deſiccated in the air.

d) This oxyd readily diſſolved in muriatic acid, and entirely, without leaving any reſidue. However, it was not perfectly free from iron; ſince the precipitate produced from it by the infuſion of galls did not exhibit that deep-yellow-red-colour, which is peculiar to the pure gallated oxyd of titanium. On this account, I cauſed the ſolution to boil upon a ſand-heat; by which management the titanic oxyd ſeparated from the liquor in the form of white gelatinous flocculi. It was then collected on the filter, and lixiviated with water, until this laſt was no longer blackened by gallic acid.

e) The titanic oxyd, again deſiccated, appeared now of a bright yellow colour, and was not attacked by acids in its preſent ſtate. To render it again ſoluble, I ignited, and urged it by heat to fuſion, with five times its quantity of carbonat of pot-aſh. The pearl-grey maſs, then produced, and ſoftened by warm water, depoſited the metallic oxyd of a perfectly white colour, weighing 230 grains, after edulcoration and drying. Muriatic acid readily diſſolved this oxyd, which now, upon trial, appeared to be pure *oxyd of titanium*, abſolutely *free from all iron*.

f) The fluids, that held the muriated iron in ſolution, were combined with cauſtic ammoniac; and the *oxyd of iron*, precipitated by that means, when moiſtened with linſeed-oil, and ignited, was found to weigh 102 grains.

With regard to the proportion of titanium to iron in menachanite, it cannot be determined in the direct way. The reaſon of this is, that the weight of the ſeparated oxyd of titanium varies very much, according to the different degrees of ſaturation with oxygen, and perhaps alſo with carbonic acid; and moreover, according to the degree of deſiccation, &c. With greater certainty may the ſtate of the iron contained in menachanite be determined; which ſeemingly agrees with that of *Ethiops martial*, or black oxyd of iron, attractible by the magnet. Allowing this, the conſtituent parts of *Menachanite* in the *hundred* may be aſſumed as follows:

Oxyd of iron, attractible by the magnet . .	51
Oxyd of titanium	45,25
Silex	3,50
Oxyd of mangameſe	0,25
	100

C.

In order to become acquainted with the habitudes of menachanite in fire, I ſubjected it to the following experiments.

a) Expoſed in a *charcoal-crucible* to the fire of the porcelain-furnace, it proved infuſible. Its grains were rendered ſomewhat more porous; its black colour had become paler, and its luſtre leſs brilliant. At the ſame time its ſurface was found overlaid with minute grains of iron.

b) But in the *clay-crucible*, the menachanite entered into perfect fuſion, and in this ſtate was imbibed by the pores of the veſſel; the places of which, that had been penetrated by the melted foſſil, were externally brown, but in the fracture black and reſplendent.

SECOND SECTION.

Ferruginous Titanite from Aſchaffenburg.

MENACHANITE is not the only inſtance of a foſſil compoſed of the oxyds of iron and titanium. Beſides that from Cornwall, ſimilar mixtures occur in various countries, differing only in the proportions of their reſpective ingredients. A proof of this is afforded by the following examination of a foſſil, which Prince *Dimitri Gallitzin* has likewiſe found in the *Speſsart* foreſt, near *Aſchaffenburg*, together with the pure titanite deſcribed and examined in the preceding ſection. The ſpecimens given me for the ſake of this enquiry, by that zealous promoter of mineralogical ſcience, are of various ſizes; the largeſt is two inches long, one inch broad, and half an inch high. Moſt of them are free from the *veinſtone*, or matrix; but ſome are embodied in a grey, flat-conchoidal quarz (*Fettquarz).* Their colour is iron-black, accompanied outwardly by a moderate, but inwardly by a ſtronger, metallic luſtre. The foſſil itſelf is compact and opake. Its fracture is uneven, and of a fine grain; its fragments indeterminately angular. It is very brittle, hard, and is only with difficulty ground to a ſubtle powder, which has a black colour. Its ſpecific gravity is 4,740.

By the magnet this foſſil is not in the leaſt attracted, not even its ſmalleſt ſplinters; nor does it itſelf attract the leaſt particle of iron. The more remarkable is it, therefore, that it is poſſeſſed of the property of indicating, like the loadſtone, the adverſe poles, by contrarily attracting and repelling either end of the poles of the magnetic needle, or any moveable magnetic bar.

a) One hundred grains of the foſſil, finely pulverized, were boiled down to dryneſs upon a ſand-bath, in a poliſhed iron-crucible, with two ounces of alkaline lye, one half of which conſiſted of cauſtic alkali. The veſſel was then placed between burning charcoal, urging the heat to the ignition of the maſs; whereby it fuſed with the conſiſtence of a thick ſyrup. The refrigerated maſs was of a dirty browniſh hue. On being ſoftened with water, its undiſſolved part ſubſided as an incoherent, reddiſh-brown powder, weighing 144 grains, after waſhing and deſiccation. The alkaline liquor was deſtitute of colour, and had taken up nothing of the foſſil.

b) Upon theſe 144 grains a ſufficient quantity of muriatic acid was poured, and again evaporated from it nearly to dryneſs. On diluting this combination with water, an iſabella-yellow precipitate fell down from it. This laſt, collected on the filter, edulcorated, and dried, and then heated to fuſion with five times its quantity of carbonated pot-aſh, yielded a grey-white maſs, from which, after dilution with water, I obtained a yellowiſh-white powder, which, cleared by waſhing from the ſaline particles, and deſiccated, weighed 45 grains. It alſo, when accurately examined, ſhewed evidently, that it was *oxyd of titanium.*

c) The portion of iron, ſuſpended in the muriatic ſolution, was precipitated by cauſtic ammoniac, and, when collected, it was moiſtened with linſeed-oil, and ſubjected to a low red-heat. This *iron* weighed 78 grains, and the whole of it obeyed the magnet.

As, therefore, no other conſtituent part exiſted in the foſſil, I may fairly conſider the remaining part as its *titanic* portion. According to which, an *hundred* parts of the foſſil contain:

Oxyd of iron . .	78
Oxyd of titanium .	22
	100

THIRD SECTION.

Ferruginous Titanite from Ohlápián.

A.

At the works at *Ohlápián*, in *Tranſylvania*, where auriferous ſands are waſhed, there occurs a *titanite* mixed with leſs iron. It conſiſts of compreſſed, or flat, rounded grains, for the moſt part of the ſize of a lentil, in which, now and then, ſlight traces of a deſtroyed cryſtalline form are obſervable. Its colour is greyiſh-black, inclining to the browniſh-red. It is opake; externally of a middling, internally of a brighter, metallic luſtre; of a lamellar texture; very hard, brittle; and reducible, by grinding, to a greyiſh-brown powder. Its ſpecific gravity is 4,445.

If heated alone before the blow-pipe, it ſuffers no ſenſible alteration. Nor does the magnet ſhew any action upon this foſſil, either in the rough ſtate, or roaſted.

This foſſil is one of the mingled heterogeneous parts conſtituting the auriferous ſands at Ohlápián, which conſiſt of very unequal grains, as well with regard to their ſhape or form as to their bulk. Of theſe accumulated ſands, the larger grains conſiſt, for the greateſt part, of this titanic ore.

The middle-ſized grains are partly light-crimſon, partly carmine-red. They are opake, and have half a line, ($\frac{1}{24}$ of an inch) in diameter. They bear great reſemblance to ſpinell, or, on account of their conchoidal fracture, to the ruby, or red ſapphire.

The ſmalleſt of them, which ſeem to be *grains of quarz*, are yellowiſh-white, very tranſparent, or ſemi-pellucid, acute angular, and in their diameter hardly $\frac{1}{120}$ part of an inch wide.

Of this laſt ſize there exiſt alſo many fine black grains in the general maſs, which probably are likewiſe *titanium*.

Theſe, and the granular quarz, conſtitute by far the greateſt part of the whole. The mingled heap, from *one ſixth* to *one fourth* part, conſiſts of the red grains; but the larger titanic grains lie but ſparingly diſtributed among them.

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a) *Two hundred* grains (by weight) of theſe minute titanites, previouſly pulverized, were mixed with a lixivium made of 600 grains of cauſtic pot-aſh in a ſilver veſſel, and after being evaporated to dryneſs, gently ignited for half an hour. This maſs came out of the fire of a verdigris colour, with brown-red ſpeckles. When diffuſed in water, and paſſed through the filter, it left on the paper a looſe, bright, and brown-red powder. The filtered alkaline liquor had at firſt a deep-green colour, but which ſoon diſappeared; and it depoſited *oxyd of mangneſe*, weighing four grains after ignition. When this precipitate had been removed, I ſaturated the fluid with muriatic acid, which threw down a whitiſh precipitate, turning yellow upon deſiccation, and conſiſting of *oxyd of titanium.*

b) This brown-reddiſh powder I boiled in a ſand-heat with muriatic acid, evaporating it afterwards nearly to dryneſs. By this treatment the maſs aſſumed a yellow colour, like the yolk of eggs. It was in the next place diluted with water, and the white *oxyd of titanium*, ſeparating from the fluid, was collected on the filter.

c) This oxyd, being lixiviated and deſiccated, together with the titanic oxyd obtained at (*a*), was mixed and fuſed in a porcelain-veſſel with ſix times their weight of carbonated pot-aſh. This united maſs, when re-diſſolved in hot water, depoſited a very white, pure *oxyd of titanium*, now ſoluble in all acids; which in this ſtate of purity, and after waſhing and exſiccation, amounted to 275 grains.

d) Cauſtic ammoniac precipitated the *oxyd of iron*, that was held in ſolution by the muriatic fluid (*b*). This being collected, waſhed, and expoſed, with ſome linſeed-oil, to a gentle red-heat, was found to weigh 28 grains.

On calculating by the method noticed in treating of menachanite, it appears that an *hundred* parts of this *foſſil from Oblápián* conſiſt of:

Oxyd of titanium	84
Oxyd of iron	14
Oxyd of mangneſe	2
	100

B.

B.

By this difference diſcovered in thoſe three foſſils, with reſpect to the proportion of their two chief conſtituent parts to each other, their claſſification in the mineralogical ſyſtem is rendered ſomewhat difficult.—If the predominant conſtituent parts be aſſumed as the baſis of a mineralogical arrangement, the *foſſil from Ohlápián* will take its place as a ſpecies of the titanium genus, under the name of *ſidero-titanium*; but the *menachanite*, together with the *foſſil from the Speſsart*, would conſtitute a new ſpecies belonging to the genus of iron, and obtain the denomination of *titano-ſiderum.*

To conclude: as, beſides in the foſſils here treated of, I have diſcovered in various others, of the genus of iron, ſome traces of this new metallic ſubſtance (as, for example, in the ſmall *magnetic iron-grains from Ceylon*, which are often found there in conſiderable quantity, on waſhing the collected hyacinth, and other ſmall looſe fragments of gems), it is neceſſary, that for the future, in the more accurate examinations of the iron ſtones and ores of iron, regard ſhould alſo be had to *titanium*, as one of their poſſible ingredients.

LX.

CHEMICAL EXAMINATION

OF THE

GARNET-SHAPED ORE of Manganeſe.

IN the granitic rocks of the *Speſsart*, near *Aſchaffenburg*; whoſe chief aggregate parts are coarſe-granular fel-ſpar, moſt frequently of a fleſh-red, grey-quartz, and a little ſilvery-white mica; there likewiſe ſometimes occur, as acceſſary ingredients, ſome black priſmatic ſhörls, but, ſtill ſeldomer, a foſſil, hitherto unknown; the analyſis of which I have made the ſubject of the preſent eſſay, and which, in the mean time, I deſignate by the name of *garnet-ſhaped ore of manganeſe*.

The merit of its diſcovery belongs to *Prince Dimitri Gallitzin*; and that of the deſcription of its external characters, here ſubjoined, to Mr. *Karſten*.

" The varieties of this foſſil moſt recently collected poſ-
" ſeſs a *deep-hyacinthine red* colour, which, in ſome, changes
" to the *reddiſh*, *or yellowiſh-brown*; and ſome burſt pieces,
" that appear to have already ſuffered ſome decay, are in-
" wardly ſpotted *greeniſh*.

" Their form of cryſtallization is not quite diſtinct; *no*
" *perfect cryſtals* having been yet found. But to judge
" from the fragments inſpected, as well as from the caſts,
" (the originals of which exiſt in the cabinet of *Prince*
" *Gallitzin)*, their leading figure ſeems to be a *double eight-*

" *ſided*

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" *ſided pyramid*, ſharpened off on both ends with four ſur-
" faces. This pointed termination is *more flat*, and all
" the angles are *more rhombic*, than in the garnet. Their
" edges are partly without truncation, and partly in a re-
" verſed order; ſo that two and two joined to each other
" have their faces formed by the truncation, but the third
" remains entire. Thoſe cryſtals are in part of a *middling*
" *ſize*, in part *ſmall*, and *very ſmall*, all of them *imbedded*
" in granite.

" Externally they are *finely*, and, as it ſeems, *alternately*
" *ſtriated.*

" At the ſame time they are *ſhining*. The ſmalleſt va-
" rieties alone, in which the ſtriæ almoſt entirely eſcape
" obſervation, are ſtrongly reſplendent, of a luſtre between
" the gloſs of fat and the brilliancy of the diamond.

" Internally, (where the foſſil is undecayed) it is through-
" out *very reſplendent*, of a fine diamond luſtre.

" Its *fracture* is in *two directions*; namely, thoſe which
" correſpond with the ſtriæ, *straight-laminated*; but in all
" other directions, making an angle with the ſtriæ, *ſmall*
" *conchoidal.*

" The *fragments* appear to be angular, of an indefinite
" form.

" In thoſe ſpecimens which I have before me, I do *not*
" perceive *detached* or *inſulated pieces.*

" The foſſil is alſo *strongly tranſparent*, more or leſs, on
" the edges.

" *Semi-indurated*, in a higher degree than pitchſtone;
" Very *brittle*; and *not* particularly *heavy*.
" Its *ſpecific gravity*, at a mean ratio, I have found to
" be 3,600."

A.

a) Ignited by itſelf upon charcoal, this foſſil is by degrees converted into a round greeniſh-black globule.

b) By borax it is gradually diſſolved into a clear olive-green pearl.

c) Neutral phoſphoric ſalt acts upon it only in a languid and imperfect manner, and forms with it by ſolution a very rifty globule, of a faint amethyſtine tinge. If nitre be projected upon it, while red-hot, the ſalt remaining upon the charcoal, after detonation, acquires ſome deep amethyſt-red ſpots.

B.

a) *Hundred* grains yielded, by grinding to fineneſs, a reddiſh-yellow powder. This was covered with a lye containing 300 grains of carbonated pot-aſh; and when previouſly inſpiſſated to dryneſs, it was ſubjected to red-heat. The ignited deep-green maſs, diffuſed in water and filtered, afforded a lixivium of the ſame colour. By ſaturating it with nitric acid, its green colour was changed to a red. When expoſed to a warm temperature, all its colour diſappeared, and the fluid depoſited brown flocculi, which, collected, weighed 4½ grains.

b) The lixiviated reſidue was of a deep black-brown, and weighed, upon deſiccation, 141 grains. Nitric acid, with which it was digeſted, ſhewed by itſelf alone no ſolvent power upon it; but attacked it only when I added ſugar to the mixture. The black-brown colour of the mixture diſappeared; and from the ſolution, now become clear, *ſiliceous earth* ſeparated, amounting to 35 grains, upon edulcoration and red-heat.

c) To the clear, bright-yellow, nitric ſolution, cauſtic ammoniac was added to exceſs of ſaturation. A light-brown precipitate enſued. The remaining colourleſs fluid, reduced by evaporation to a ſmaller volume, continued unchanged, on combining it with carbonated pot-aſh.

d) I re-diſſolved this precipitate (*c*) in muriatic acid, and treated the ſolution, firſt with leſs cauſtic pot-aſh than was required to neutralize the little predominant portion of uncombined acid. Upon this, I added to it a ſolution of 400 grains of tartrite of pot-aſh (*tartarus tartariſatus*), which produced a copious, ſtraw-yellow precipitate, in fine grains. The whole mixture was again evaporated to dryneſs, then ſtrongly ignited in a porcelain-crucible, and the black-brown reſidue was lixiviated with a ſufficient quantity of water.

This reſidue, when dried again, together with the preceding, of 4½ grains (*a*), was once more ignited. It then appeared in the character of a fine *oxyd of manganeſe*, and weighed 49 grains.

I digeſted once more this manganeſian oxyd with nitric acid, adding ſucceſſive portions of ſugar, and, laſtly, diluting the mixture with water, and filtering it. On the paper there remained *oxyd of iron*, which, edulcorated, and heated to redneſs, weighed 14 grains; and, after a ſecond ignition with wax, was quickly attracted by the magnet. By deducting this, there remain, therefore, 35 grains for the *oxyd of manganeſe*.

f) The water employed to lixiviate the ignited maſs (*d*) exhibited now a colourleſs alkaline ſolution. When fully neutralized with muriatic acid, and treated with carbonat of ſoda, a white, looſe earth was precipitated, which, edulcorated and ignited, weighed 14¼ grains. This earth, diſſolved in ſulphuric acid, and, when made to cryſtallize by proper management, afforded, throughout the proceſs, cryſtals of *alum*.

Wherefore, *hundred* parts of this *garnet-ſhaped ore of manganeſe* have yielded:

Oxyd of manganeſe	*e*) . . .	35
Oxyd of iron . .	*e*) . . .	14
Silex	*b*) . . .	35
Alumine . . .	*f*) . . .	14,25
		98,25

LXI.

CHEMICAL EXAMINATION
OF THE
NATIVE OXYD OF TIN.

(*Tin-ſtone. Zinnſtein*).

FIRST SECTION.

Experiments in the dry way.

THE *aſſay of tin*, or the proceſs of producing metallic tin in the *dry way*, by reviving a ſmall quantity from the tin-ore, (called *Tin-ſtone*) or the *native oxyd of tin*, with the leaſt poſſible loſs of weight, has hitherto been ſubject to many difficulties. I have always obtained unequal, and hence uncertain reſults, in the repeated experiments, which I have made, according to the directions given in the elementary treatiſes on *Docimaſy*, or *Art of aſſaying Metals*; that is to ſay, by combining the tin-ores to be aſſayed with fixed alkalis, with borax, and the like. The cauſe of this failure chiefly depends on the ſolubility of the oxyd of tin in the alkaline additions, employed as fluxes in the proceſs.

On the contrary, the following *aſſays*, performed in the ſimpleſt manner, without any addition, and merely in charcoal-crucibles, have always given me much more certain, and, on repeating them, conſtant reſults, with the exception of an inconſiderable difference.

A.

Aſſays in charcoal-crucibles.

1.) *Brown, cryſtallized tin-ſtone (Zinngraupen)* from *Schlackenwalde*, in *Bohemia*, of the ſpecific gravity of 6,760. *One hundred grains* of this, in entire pieces, were introduced into the cavity of a charcoal-crucible, cloſing its orifice with a ſtopper of the ſame materials. This charcoal-crucible was then tightly inſerted and faſtened in another of baked clay, placed upon the forge-hearth before the nozzle of the bellows, and the contents of the firſt, reduced to the reguline ſtate, by directing thither a briſk current of air for half an hour. The metallic button of tin produced was a little blackiſh on its ſides, and its ſurface coated with a greeniſh cruſt. It weighed 72½ grains.

2.) *Light-brown, acicularly cryſtallized tin-ſtone (Needle-tin)* from *Polgooth*, in *Cornwall*.

The preſent differs from the many other varieties of Corniſh tin-ſtones in this, that it is an aggregate of very minute, for the moſt part capillary, four-ſided columnar cryſtals, of a light-brown colour, and vivid luſtre. Where the accumulation does not paſs into compact tin-ſtone, the ſmall interſtices are filled up by chlorite.

The ſpecific gravity of this oxyd of tin, in crude lumps, is 5,845; but when in the ſtate of picked and well waſhed ore (*Schlich*), it is 6,750.

Hundred grains of this waſhed needle-tin, reduced in the charcoal-crucible, in the ſame manner as the foregoing, afforded a button of metallic tin, weighing 77 grains, with ſome ſuperincumbent ſcoriaceous globules; which weighed two grains, and were probably ſome remnants of chloritic earth.

3.) *Cryſtallized grey tin-ſtone*, having ſome white tranſparent ſpots, from St. *Agnes*, in *Cornwall*. The ſpecific gravity of theſe cryſtals is 6,840. *One hundred* grains, treated in the ſame manner, yielded 74 grains of revived tin.

4.) *Stream-tin (Seifenzinnſtein)* from *Ladock*, in *Cornwall*. *One hundred grains* of this ore, conſiſting of looſe blackiſh grains, and of the ſpecific gravity of 6,560, were reduced in this way to 76 grains of reguline tin.

5.) *Stream-tin*, from *Alternon*, in *Cornwall*.

The colour of this, which muſt be reckoned among the pureſt tin-ores, is in ſome places darker, in others lighter. Of all the tin-ſtones, which I have weighed on the hydroſtatic-balance, I have found the preſent the moſt ponderous; its ſpecific gravity being 6,970.

The reduced, or metallic tin, obtained from *hundred* grains of this ore, weighed 76 grains.

6.) *Wood-tin*, from Cornwall.

This remarkable ſpecies, which till now is only known in ſhivery looſe fragments, or *ratchill* of the miners *(Geſchieben)*, occurs in the waſhing works of tin, in the neighbourhood of St. *Colomb*, *Roach*, and St. *Denis*, in *Cornwall*; but in ſmall quantities only. Uſually the pieces are but ſmall; thoſe that have the ſize of a bean belong to the ſcarcer ones*.

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* A ſpecimen of wood-tin, of the ſcarceſt magnitude, exiſts in the exquiſitely fine collection of *Baron Racknitz*, at *Dreſden*. It is *two* inches long, and *one* broad.

This ore, the only one of its kind, is externally diſtinguiſhed from the common tin-ſtones, chiefly by the total abſence of any cryſtalline form; while, on the other hand, it exhibits its peculiar, bundled or faſcicular fracture. Its external characters have been fully deſcribed by *Werner*[*] and *Karſten*, chiefly[†].

I found the ſpecific gravity of wood-tin-ſtone to be 6,450.

One hundred grains of it, reduced in the manner already mentioned, *viz.* ſimply in the charcoal-crucible, gave 73 grains of reguline tin.

By the ſame method, I have ſubjected to the *proceſs* of *reduction* various other tin-ſtones, as well as waſhed and pounded tin-ores, and have conſtantly obtained, in the reſult, from 72 to 77 *per cent* of reguline tin. The ſmall portion of iron, commonly contained in tin-ſtones, uſually ſticks to the ſurface of the reduced tin, in very minute grains; and it is owing to this, that the button of tin is moved when the magnetic needle is approached to this part of its ſurface.

It is worth remarking, that uſually ſmall cavities are formed in the button of revived tin, as it cools and becomes fixed; which ſmall fiſſures are covered by minute lamellæ, that, in colour and brilliancy, reſemble poliſhed gold in a very illuſive manner.

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[*] *Beobach. u. Entdeck. a. d. Naturkunde*, vol. I. Berlin, 1787, page 152.

[†] *Ibidem*, vol. IV. 1792, page 397.

B.

B.

Habitudes of Tin-ſtone, when expoſed to heat in a crucible made of clay.

1.) *Brown-tin-ſtone* from *Schlackenwalde*, expoſed to a porcelain-fire, in a baked clay-crucible, ran into a clear denſe glaſs, greeniſh-grey in the middle, but of a bright yellow on the ſides, and at top. The ſurface was inveſted with a dull whitiſh cruſt. The interior ſides of the veſſel were glazed of a milk-white, and overlaid with many ſmall groups of light-brown, tender, needle-ſhaped cryſtals. The inner ſurface of the crubible lid, had alſo ſimilar detached cryſtals adhering to it.

2.) *Needle-tin* from *Polgooth*, ſubjected in a clay-crucible to the heat of the porcelain-furnace, likewiſe produced a compact, light-browniſh, tranſparent glaſs; covered on the upper ſurface with a browniſh, dim, and ſhrivelled, or furrowed cruſt.

3.) *Stream-tin* ore from *Alternon*, committed in the ſame manner to the porcelain-furnace, in a crucible of baked clay, yielded a compact light-yellow, and ſtill ſomewhat clearer glaſs, that was found coated by a dull cruſt, of an iſabella-yellow.

SECOND SECTION.

Experiments in the humid way.

THE extreme reſiſtance which tin-ſtone oppoſes to acid menſtrua has hitherto always prevented the complete ſucceſs of its decompoſition in the *humid way*; the reaſon of muſt be ſought for in the highly intimate and difficultly deſtructible combination of tin with oxygen. To be diſſolved in acids, tin indeed, like other metals, requires a commenſurate proportion of oxygen. But if that proportion be exceeded, as is the caſe with tin-ſtone, with *putty* or *tin-aſhes* (the white, perfect oxyd of tin by ignition with acceſs of air) with the oxyd of tin corroded by nitric acid, and ſimilar other calces of that metal; the ſolution cannot take place, unleſs the exceſs of oxygen cauſing this impediment be previouſly removed.

A.

Till the preſent period, *Bergmann*[*] was the only author, who has ſhewn a method of analyſing tin-ſtone in the humid way: but unfortunately, I, as well as other chemiſts[†], have ſufficiently experienced its imperfection. However, I entertained a hope, that the proceſs recommended by him would moſt likely ſucceed when employed for wood-tin; on the ground, that of all tin-ſtones, this at leaſt yields in ſome manner to the attack of acids; as I obſerved that 60 grains of it, reduced to an impalpable powder, and ſubjected to vigorous and long continued digeſtion with three ounces of nitro muriatic acid, had loſt five grains of weight.

For this purpoſe, I digeſted 120 grains of finely pulverized *wood-tin*, for ſome time, with *one* ounce of concentrated ſulphuric acid, and the aſſiſtance of a boiling heat. After this, I added by degrees two ounces of muriatic acid, and having digeſted it once more, I diluted the whole with water, and decanted the clear fluid from the undiſſolved reſidue which ſettled at the bottom. The ſame proceſs was repeated twice with this laſt, adding each time half the above mentioned quantity of the acids. That portion, which continued inſoluble, retained its original appearance, and weighed ſtill 98 grains. The ſolution exhibited a yellow colour. When part of it was tried by Pruſſian alkali, the blue tinge manifeſted ſome latent portion of iron. The whole of the ſolution was, upon this, ſaturated with carbonated pot-aſh; which produced a dirty white precipitate, weighing 27 grains in its dry ſtate. Muriatic acid poured upon this precipitate rapidly diſſolved it; and, on plunging into the ſolution, diluted with water, a thin ſtick of metallic zinc, there ſettled round it ſubtle lamellæ of reguline tin.

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[*] *Opuſcula Phyſica et Chemica.* vol. II. page 437.

[†] *Chemiſche Annalen.* 1786. 2 Band, page 126.

Yet, although, in this way the ſolution of *wood-tin* was in part accompliſhed, it would not ſucceed with other ſpecies of tin-ſtones, treated in the ſame manner. Such acids, as have been employed for this purpoſe, diſſolved indeed the ſmall portion of iron entering into the foſſil, but exhibited ſeldom a ſlight trace of diſſolved tin; and the powder of the tin-ſtone, ſubjected to the experiment, ſuſtained only a very ſlight alteration in its appearance and weight.

Beſides this, another circumſtance connected with this method is yet to be remarked; which is, that each time, when muriatic acid is poured on the concentrated and heated ſulphuric acid, clouds of muriatic vapours ariſe, detrimental to the health of the operator.

Therefore the problem, to decompoſe, in the *humid way*, tin-ſtones, and other calces of tin, fully ſaturated with oxygen, has by no means been ſolved by the proceſs preſcribed by *Bergmann*.

B.

Among thoſe ſubſtances, which, by their near affinity with oxygen, afford a rational conjecture, that, by depriving tin-ſtone of part of its oxygen, they might prepare or render it fit for its ſolution in acids, *ſulphur* principally ſeemed to deſerve the trial.

Hundred grains of finely powdered *tin-ſtone*, from *Schlackenwaldt*, mixed with an equal quantity of ſulphur, were introduced into a ſmall glaſs-retort. This being connected with a receiver, was lodged in a ſand-bath, and gradually heated to an incipient ignition of its contents. When this proceſs was accompliſhed, I found the ſulphur ſublimed, without any change in its natural ſtate; while the reſidue, which preſerved the former white-grey colour of the pulverized tin-ſtone, was hardly conglutinated, but had here and there ſome ſolitary, very minute, glittering, golden-yellow ſcales of *aurum muſivum* ſpread on its ſurface. This reſidue was ſtrongly digeſted with muriatic acid. But although the muriatic fluid, ſeparated from it by filtering, had, on combination with alkali, afforded ſome oxyd of tin; yet its quantity was too inconſiderable, to make it reaſonable to expect in this way a complete ſolution of tin-ſtone.

C.

After the above mentioned, and ſeveral other unſucceſsful attempts, I proceeded to the application of *cauſtic-potaſh*. It was with ſatisfaction, that I found in this the means of accompliſhing my purpoſe: ſo fully, that at preſent the *complete analyſis of tin-ſtone in the humid way* is no longer ſubject to any difficulty.

1. *a*) One *hundred* grains of tin-ſtone from *Alternon*, in *Cornwall*, previouſly ground to a ſubtle powder, were mixed in a ſilver-veſſel with a lixivium containing 600 grains of cauſtic pot-aſh. This mixture was evaporated to dryneſs in a ſand heat, and then moderately ignited for half an hour. When the grey-white maſs, thus obtained, had been ſoftened while yet warm, with boiling water, it left on the filter 11 grains of an undiſſolved reſidue.

b) Theſe 11 grains, again ignited with ſix times their weight of cauſtic pot-aſh, and diſſolved in boiling water, left now only 1¼ grain of a fine yellowiſh-grey powder behind.

c) The alkaline ſolution (*a* and *b*), which was in ſome degree colourleſs, was ſaturated with muriatic acid. A brilliant white, tender oxyd of tin was thrown down, giving to the mixture a milky appearance. This precipitate, re-diſſolved by an additional quantity of muriatic acid, was precipitated afreſh by means of carbonated ſoda. When lixiviated and dried in a gentle heat, it acquired the form of bright-yellowiſh, tranſparent lumps, having in their fracture a vitreous luſtre.

d) This precipitate, being finely powdered, ſoon and entirely diſſolved in muriatic acid, aſſiſted by a gentle heat. Into the colourleſs ſolution, previouſly diluted with from two to three parts of water, I put a ſtick of zink; and the oxyd of tin, thus reduced, gathered around it in delicate, dendritic laminæ of a metallic luſtre. Theſe, when collected, waſhed, dried, and fuſed, under a cover of tallow, in a capſule placed upon charcoal, yielded a button of pure metallic tin, weighing 77 grains.

e) The above mentioned reſidue of 1¾ grain, left by the treatment with cauſtic pot-aſh (*b*), afforded with muriatic acid a yellowiſh ſolution ; from which, by means of a little piece of zink introduced into it, ½ grain of tin was ſtill depoſited. Pruſſian alkali, added to the remainder of the ſolution, produced a ſmall portion of a light-blue precipitate ; of which, after ſubtracting the oxyd of tin now combined with it, hardly ¼ of a grain remained, to be put to the account of the iron contained in the tin-ſtone, here examined.

In theſe experiments, (excepting only a ſlight indication of *ſilex* amounting to about ¾ of a grain), no trace has appeared, either of tungſtenic oxyd, which ſome Mineralogiſts have ſuppoſed to be one of the conſtituent parts of tin-ſtone, nor of any other fixed ſubſtance. Therefore, what is deficient in the ſum, to make up the original weight of the foſſil analyſed, muſt be aſcribed to the loſs of oxygen ; and thus the conſtituent parts of *pure tin-ſtone from Alternon* are to each other in the following proportion :

Tin	77,50
Iron	0,25
Silex	0,75
Oxygen	21,50
	100

2.) I repeated the ſame experiment with waſhed *needle-tin* from *Polgooth*, and obtained nearly the ſame reſult.

3.) *Hundred* grains of *brown tin-ſtone* from *Schlackenwalde*, decompoſed in the ſame manner, by means of cauſtic alkaline lye and muriatic acid, yielded 75 grains of reguline tin ; but its portion of iron amonnted to ½ grain.

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LXII.

CHEMICAL EXAMINATION

OF THE

NATIVE SULPHURET OF TIN[*].

(Tin-pyrites. Zinnkies.)

THE *Tin-pyrites*, or *ſulphuret of tin*, which at *Wheal Rock*, in the pariſh of St. *Agnes*, in *Cornwall*, at the depth of 20 fathoms under ground, forms a vein of 9 feet in thickneſs, is the firſt, and as yet the only inſtance of a natural tin-ore mineralized by ſulphur. *Bergmann*[†], it is true, mentions ſuch an ore as coming from Siberia; but it has never yet been found there; and what this celebrated chemiſt has conſidered as ſuch, and examined, was not a true foſſil, but a ſuppoſititious product of art[‡].

The colour of this tin-pyrites is grey, of various degradations from the light to the dark, and in the purer ſpecimens approaching to the ſilvery white. It is found in ſmall lumps, poſſeſſes a moderate metallic luſtre, and exhibits an uneven, ſmall-grained fracture. Its texture appears to be foliated, and its fragments are, for the moſt part, indeterminately angular. It is alſo very brittle, and eaſily triturated*. Its ſpecific gravity, as I found, is 4,350.

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[*] *Beob. u. Entdeck. a. d. Naturkunde.* vol. I. pages 155 and 169.

[†] *Opuſc. Phys. et Chem.* vol. III. page 158.

[‡] *Crell's Chem. Annalen.* 1790. vol. I. page 53.

According to the following analyſis, the conſtituent parts of this ore are *Tin*, *Copper*, *Iron*, and *Sulphur*. For this reaſon, the name of *Bell-metal ore* has been given it, not very improperly.

Tin pyrites contains, beſides the copper chemically mixed with it a sone of its conſtituent parts, likewiſe copper-pyrites; which in part is coarſely, and in part finely diſſeminated in it. From this accidental ingredient, I previouſly freed, as much as poſſible, the tin-pyrites, or native ſulphuret of tin, ſubjected to the following examination.

A.

Half an ounce of tin-pyrites was heated to redneſs in a ſmall glaſs-retort. In the receiver a moiſture was found, making about two drops, impregnated with ſulphureous acid. The neck of the retort became thinly lined with a little grey and yellow ſublimate, of about $\frac{1}{4}$ grain of weight; which, when placed on a glowing coal, firſt ſmelled and burned like ſulphur; but after this, a faint odour of arſenic was perceptible. The tin-pyrites loſt three grains of weight.

B.

Two drachms of tin-pyrites were roaſted in a calcining-pot, till no longer any ſulphureous ſmell could be obſerved.

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* A more detailed deſcription of the external properties of tin-pyrites, by *Karſten*, may be ſeen in *Beob. u. Entd. a. d. Naturkunde*. vol. IV. page 391.

By this the ore was converted into a red calx or oxyd, weighing two drachms and 20 grains. It was then mingled with equal parts of calcined borax, half a part of white glaſs, and one fourth part of colophony. Being introduced in this ſtate into an aſſay-crucible (*Tute*), lined with powdered charcoal, and covered with common ſalt, it was kept in a ſtate of ſtrong fuſion for half an hour: by which treatment it yielded a metallic button of a grey colour, 10 grains in weight, but very brittle; ſo much ſo, that by a gentle ſtroke with the hammer it flew in pieces. The remainder of the reduced metal lay diſperſed in ſmall grains among the pulverulent ſcoriæ, mingled with the charcoal-duſt, that was employed to line the veſſel.

C

a) *Two drachms* of finely triturated tin-pyrites were treated with an aqua regia, compoſed of one ounce of muriatic and ½ ounce of nitric acid. Within 24 hours the greateſt part of the metallic portion was diſſolved in it, without application of heat; while the ſulphur roſe up, and floated on the ſurface of the menſtruum. After the mixture had been digeſted upon it for ſome time in a low ſand-heat, I diluted it with water, and filtered it. It left 43 grains of ſulphur on the paper, ſtill, however, mixed with metallic particles. When the ſulphur had been gently burnt off on a teſt, there ſtill remained 13 grains; of which eight were diſſolved by nitro-muriatic acid. The remaining part was then ignited with a little wax; upon which the magnet attracted one grain of it.—What remained was part of the ſiliceous matrix, and weighed three grains.

b) The ſolution of the metallic portion (*a*) was combined with carbonat of pot-aſh; and the dirty-green precipitate,

pitate, thus obtained, was re-diſſolved in muriatic acid, diluted with three parts of water. Into this fluid a cylinder of pure metallic tin, weighing 217 grains, was immerſed. The reſult was, that the portion of copper contained in the ſolution, depoſited itſelf on the cylinder of tin; at the ſame time that the fluid began to loſe its green colour, from the bottom upwards; until, after the complete precipitation of the copper in the reguline ſtate, it became quite colourleſs.

c) The copper thus obtained weighed 44 grains. By briſk digeſtion in nitric acid, it diſſolved, forming a blue tincture; and left one grain of tin behind, in the character of a white oxyd. Thus the portion of pure copper conſiſted of 43 grains,

d) The cylinder of tin, employed to precipitate the copper, now weighed 128 grains; ſo that 89 grains of it had entered into the muriatic ſolution. From this, by means of a cylinder of zinc, I re-produced the whole of its diſſolved tin, which was looſely depoſited on the zinc in a tender dendritical form. Upon being aſſured, that all the tin had been precipitated, I collected it carefully, lixiviated it cleanly, and ſuffered it to dry. It weighed 130 grains. I made it to melt into grains, having it previouſly mixed with tallow, and under a cover of charcoal duſt, in a ſmall crucible; which done, I ſeparated the powder of the coal by elutriation. Among the waſhed grains of tin, I obſerved ſome black particles of iron, which were attracted by the magnet, and weighed one grain. Deducting this, there remain 129 grains for the weight of the tin. By ſubtracting again from theſe laſt thoſe 89 grains, which proceeded from the cylinder of tin employed for the precipitation of the copper (*b*), there remained 40 grains for the portion of tin contained in the tin-pyrites examined. Hence, including that one grain of tin, which had been ſeparated from the ſolution of the copper (*c*), the portion of pure tin contained in this ore amounts to 41 grains.

The *educts*, or ſubſtances, extracted in this proceſs from tin pyrites, were conſequently:

Sulphur	30 grains.
Tin	41
Copper	43
Iron	2
Vein-ſtone, or *gangue* .	3
	119

Which makes in an *hundred* parts:

Sulphur	25
Tin	34
Copper	36
Iron	2
	97

However, this proportion of the conſtituent parts is not always conſtant. The darker varieties of tin-pyrites, in particular, are conſiderably poorer in tin; as, from one of them I ſcarcely obtained one half of the above quantity of reguline tin: but their proportion of iron increaſes.

D.

Although, in the courſe of theſe experiments, no trace of any ſilver, or lead, which had been ſuſpected to exiſt as an ingredient in this foſſil, had appeared; yet, for the ſake of greater certainty, I inſtituted the following trial. The tin-pyrites, that had been ignited in the retort (A) was treated with nitric acid; which attacked it, emitting copious red vapours. After ſufficient digeſtion, I diluted the mixture with water, and ſeparated the remaining ſulphur and oxyd of tin by means of the filter; combining, afterwards, the clear, blue ſolution, both with muriatic and ſulphuric acids. But, by its continuing clear and unchanged, it ſhewed that neither ſilver nor lead are preſent in this ore.

E.

The ready ſolubility of tin, contained in this ore, in the nitro-muriatic, as well as in the muriatic acid, which does not take place in tin-ſtones, and all other oxyds of tin fully ſaturated with oxygen, is a ſufficient proof that, in this ore, the tin held in ſolution by the ſulphur, in a manner, approaches the ſtate of native, or reguline tin. This is farther corroborated by the following experiment.

1. *a*) I expoſed *half an ounce* of tin-pyrites, mixed with the ſame quantity of corroſive ſublimate, to a ſand-heat, in a ſmall retort, connected with a receiver. At the very firſt moderate action of the fire, a heavy fluid paſſed over, attended with heavy white vapours; and, on the increaſe of heat, a grey-yellow ſublimate, for the moſt part cryſtallized in needles, ſettled on the neck of the retort; at the ſame time that on its upper convexity an impure black-grey cinnabar, or ſulphuret of mercury, depoſited.

b) The ſtrongly-fuming fluid in the receiver, which gave out thick white fumes, weighed one drachm, and perfectly reſembled common *fuming liquor of Libavius*, or ſublimed ſolution of muriat of tin. From this, by dilution with water, and ſaturation with pot-aſh, the oxyded tin was thrown down, as a white, very tumid precipitate, which, edulcorated and dried, weighed 30 grains.

c) The

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c) The ſublimate, ſeparated from the neck of the retort, was pulverized, digeſted with water, and filtered. The reſidue which it left on the paper amounted to 203 grains, when deſiccated. Theſe were diſſolved in nitro-muriatic acid, with the exception of 15 grains of ſulphur; and the mercury fell down, in the reguline ſtate, from the ſolution, by putting copper into it. The aqueous ſolution of the ſublimate, obtained by the digeſtion, and precipitated by carbonat of pot-aſh, afforded 16 grains of oxyded tin; which were added to the preceding (*b*).

d) The oxyd of tin was then diſſolved in muriatic acid, and again precipitated, in the metallic ſtate, by a piece of zinc, plunged into the ſolution. This reguline tin, when collected, waſhed, and melted with tallow, weighed 20 grains. I flattened it by beating with the hammer; cut it into pieces; digeſted it with nitric acid; and dropped Pruſſian alkali into the fluid, filtered off from the oxyd of tin. The few brown flocculi precipitated by that alkali, proved that the muriated tin had carried along with it a ſlight portion of copper.

2.) By way of a comparative experiment, I repeated this proceſs with a ſpecies of pure *tin-ſtone*; but, in this caſe, not the leaſt trace appeared of any ſolution of the tin. The mercurial ſublimate volatilized in its uſual needled form, and the tin-ſtone remained in the retort unaltered.

LXIII.

LXIII.

CHEMICAL EXAMINATION
OF THE
MOLYBDAT OF LEAD,
(*Yellow Lead-ore*),
From BLEIBERG.

FIRST SECTION[*].

1.) THE *yellow lead-ore*, or *Molybdat of Lead*, from *Bleiberg*, near *Villach*, in *Carinthia*, conſtitutes, in the genus of lead, a particular, very diſtinguiſhed ſpecies of ore, occurring in many beautiful varieties. Its colour is waxy-yellow, of various ſhades; ſome inclining to the reddiſh, others to the whitiſh-grey. For the moſt part it is cryſtallized in tables, of from four to eight ſides, which ſometimes ſtand ſingly on their edges, or narrow ſides, and, at times, are cellularly concreted. Thoſe ſpecimens of it are rather ſcarce in which the cryſtals form a cube, or an octahedron, inſtead of a table.

The matrix, in which this ore is imbedded, is a compact lime-ſtone, of a yellow, whitiſh, or grey colour.

2.) Moſt mineralogiſts ſeem to have become acquainted with this lead-ore, only ſince the time that *Jacquin*[†] publiſhed his treatiſe on it; after whom *Wulfen*[‡] has contributed to the knowledge of this ore, by the elegant and accurate deſcription which he has given of it. As to the conſtituent parts of the yellow lead-ore, the following experiments will ſhew that the ſubſtance with which the lead is combined in this mineral is not the oxyd of tungſten, as has been erroneouſly ſuppoſed, but the *oxyd of molybdena.*

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[*] *Beob. u. Entdeck. a. d. Naturkunde.* vol IV. 1792, page 95; and vol. V. 1794, page 105.

[†] *Miſcellanea Auſtriaca.* vol. II. Vienna, 1787.

[‡] *Xav. Wulfen. Abhandlung vom Kärnthner Bleiſpathe.* Wien, 1785.

3.) The firſt point which I had in view, was to ſeparate this lead-ore carefully from the adhering extraneous parts. Finding that diluted nitric acid ſhewed in the cold no action on this foſſil, I affuſed upon the quantity of it deſtined for this analyſis ſmall portions of this acid; pouring it off again as ſoon as the effervescence ceaſed. This proceſs I repeated, till, at laſt, no more effervescence enſued on adding a freſh portion of the acid. Upon this the ore was waſhed with water, and deſiccated. The nitric acid employed for this purification contained the calcareous earth proceeding from the matrix, which outwardly adhered to the ore, and formed gypſum with ſulphuric acid, by means of which I precipitated it. At the ſame time, a conſiderable portion of a fine, red iron-ochre was waſhed off by this proceſs, which diſſolved by digeſtion in muriatic acid, leaving a ſlight reſidue, conſiſting of lead-ore and ſiliceous earth.

4.) *Two drachms* of the above-mentioned cryſtals of lead-ore, thus purified, were mixed with an equal quantity of carbonated pot-aſh, and expoſed to the fire in a ſmall crucible. It entered into fuſion without effervescence. The refrigerated maſs exhibited a faint reddiſh tinge, and was covered on its upper part with ſcales, reſembling litharge. Having ſoftened this alkaline maſs with water, and filtered, I ſaturated the colourleſs ſolution with nitric acid. By this the mixture was not rendered very turbid; but, on the next day, I found the bottom of the glaſs covered with tals of ⅛ of an inch long, ſtanding upright; which I examined as follows:

a) Their figure conſiſts of ſmall, brilliant, accumulated rhomboidal tables.

b) On the tongue they manifeſt a weak metallic taſte.

c) Under the blow-pipe, upon charcoal, they fuſe very quickly and calmly into little globules, or drops, which are inſtantly imbibed by the ignited coal.

d) In the ſilver ſpoon they melt into grey ſpherules, which become ſhrivelled as they cool; and, during the current of air, urged through the blow-pipe, they depoſit a white ſubſtance, which covers the ſpoon.

e) When put upon a globule of alkaline phoſphat, fuſed on the charcoal, they are rapidly diſſolved, and tinge it either of a graſs, or olive-green, according to the quantity in which they are added.

f) They entirely diſſolve in water, by the aſſiſtance of heat.

g) Pruſſian alkali produces from this ſolution a copious, flocculent precipitate, of a *light-brown* colour.

h) If, into the aqueous ſolution (*f*) a little muriatic acid be dropped, and a ſmall piece of tin be put into it; or, if ſome of thoſe cryſtals are immerſed in a muriatic ſolution of tin; in both theſe caſes the fluid acquires a *deep-blue* colour.

In conſequence of thoſe appearances, I think I did not err in conſidering theſe cryſtals as *molybdic acid*, neutraliſed by pot-aſh; becauſe, in a comparative experiment, the ſame relations were ſhewn by molybdic acid, that had been prepared from molybdena of *Altenberg*, by detonation with nitre, and ſubſequent precipitation, effected by nitric acid, from the filtered ſolution of the maſs produced by the detonation, and which acid likewiſe aſſumed a cryſtalline form in drying.

5.) As it was obvious, from the ſtate of the calciform lead, which remained on the paper when I filtered the ſolution of the fuſed maſs (4), that the whole of the yellow lead-ore employed had not been decompoſed, I repeated the experiment, increaſing, however, the proportion of the alkali; ſo that, for two drachms of the ore, I took 10 drachms of carbonated pot-aſh. I alſo kept the maſs for a ſomewhat longer time in fuſion; after which it was poured out, levigated, ſoftened with water, and thrown upon the filter. This alkaline ſolution I ſaturated with muriatic acid, at firſt only incompletely; whereby, at a warm temperature, a white precipitate was produced, in the form of a cheeſy coagulum. This precipitate contained, indeed, molybdic oxyd, but mixed with a greater portion of oxyded lead; which laſt, upon ſolution in muriatic acid, ſeparated in needle-ſhaped cryſtals of muriat of lead.

When this precipitate had been ſeparated from the alkaline ſolution, which before was ſaturated with only half the quantity of muriatic acid required, I combined that fluid with an additional portion of the ſame acid to its complete ſaturation. It became again turbid, but only moderately ſo. Upon this, a white precipitate accumulated, like ſtarch, ſubſiding in cold water; which, carefully edulcorated and dried, was examined in the ſame manner as the cryſtalline precipitate mentioned before, (4). Its habitudes were perfectly the ſame; except that it would not diſſolve

alone

alone in water, but formed a clear ſolution, only when a few drops of muriatic acid had been added.

The fluid was now concentrated by evaporation; after which the oxyd of molybdena, ſtill contained in it, fell down as a fine, *heavy*, *yellow powder*; which, after proper lixiviation and drying, exhibited a beautiful, ſaturated lemon-colour.

6.) The white oxyd of lead, which remained upon the paper on filtering the ſoftened maſs, produced by the fuſion of the ore with pot-aſh (4), was found contaminated with a portion of ſiliceous earth. When treated upon charcoal, it did not entirely melt into a metallic button; but part of it was converted into a clear, bright, yellow globule of glaſs of lead (vitreous oxyd): for the admixed ſiliceous earth prevented the reduction of the whole portion of lead; in the ſame manner, as is the caſe when it is attempted to reduce upon charcoal a glaſs of lead, that has been made of three parts of oxyded lead and one of ſilex. For this reaſon, I diſſolved the above-mentioned oxyd of lead in dilute nitric acid, ſeparated the ſiliceous earth by filtration, and precipitated the metal from the ſolution, by means of ſulphuric acid, in the character of ſulphated lead.

7.) I likewiſe examined the actions of ſome of the acids upon this *Carinthian lead-ore*.—One drachm of it was digeſted with a copious quantity of nitric acid; which diſſolved the greateſt part, but not the whole of it. In the ſolution were obſerved white, looſe flocculi diſperſed, which dried upon the filtering paper in the form of a membrane, and became tarniſhed of a blue by expoſure to daylight. This ſubſtance had much reſemblance to the molybdic oxyd, obtained from molybdena in the humid way, by repeatedly diſtilling nitric acid from it. The filtered nitric ſolution contained, beſides the portion of lead, a conſiderable quantity of molybdic oxyd. Sulphuric acid precipitated the lead from it; and Pruſſian alkali afterwards threw down the molybdena in looſe, brown, red particles.

8.) *One drachm* of this yellow-lead ore, previouſly purified, afforded a clear ſolution, by digeſtion with muriatic acid. The ſolution went on gradually, and was nearly complete and colourleſs; but it ſoon depoſited white cryſtals of muriated lead. Only a ſlight portion of ſilex was left behind, which I ſeparated. While I was concentrating the fluid, the ſaline cruſt ſettling on the ſides of the evaporating diſh became tarniſhed of a fine blue; which as often diſappeared as the cruſt was re-diſſolved in the fluid, on gentle agitation. When the concentrated fluid had been decanted from the muriat of lead, which ſtill ſubſided, it aſſumed a beautiful deep-blue, but loſt that colour again by dilution with water. When afterwards ſaturated with potaſh, it dropped a white oxyd of molybdena.

9.) *Oxyd of lead*, and *oxyd of molybdena*, therefore, are the conſtituent parts of the *yellow lead-ore* from *Bleiberg*, in *Carinthia*. This combination is remarkable, as it is the firſt inſtance of the kind; ſince molybdena has not yet occurred any where, except in its proper ore (*Waſſerbley*). From the foregoing experiments there alſo reſult ſome other obſervations, by which the knowledge of the chemical properties of that metallic ſubſtance (*molybdena*) is greatly enlarged. To theſe belongs its external form, as it occurs partly in the cryſtalline ſtate, partly as a white, and partly as a lemon yellow oxyd. In the *firſt* ſtate, it is ſoluble in ſimple water, as well as in acids; in the *ſecond*, a ſmall addition of muriatic acid promotes its ſolution in water; but in the third, or that of a yellow oxyd, it refuſes to diſſolve both in water and in acids. The cauſe of this difference conſiſts in this, that in the two firſt caſes it has been neutralized with the portion of alkali that remained combined with it; whereas, in the laſt caſe, that is, in the form of a yellow earth, it is more in the ſtate of a mere metallic oxyd.

10.) This appearance of the molybdic oxyd with a yellow colour, has probably been the reaſon for conſidering the ſubſtance, by which this yellow lead-ore is mineralized, as tungſtic acid.

However, the blow-pipe alone is ſufficient to diſtinguiſh theſe two metallic ſubſtances from each other; for, the yellow *molybdic oxyd* loſes its colour at the firſt contact with the point of the flame, and is rendered *olive-green*; it alſo immediately runs into a ſmall globule, or drop, which is very ſoon abſorbed by the charcoal; and, laſtly, when fuſed with a neutral phoſphat, it tinges the button which thence ariſes of a *green* colour.

The *yellow oxyd of tungſten*, on the contrary, exchanges, by ignition, its yellow colour for a *blue* or *black*, at the ſame time that it remains upon the charcoal as perfectly infuſible; and when fluxed with phoſphoric ſalt, it gives a *ſky-blue* colour to the ſaline globule.

SECOND SECTION.

HAVING thus obtained, by means of the experiments here explained, the knowledge of the *conſtituent* parts of the *yellow lead-ore* from *Carinthia*, I had yet to diſcover their *proportions* to each other. This I accompliſhed in the following way.

a) *A hundred* grains of the cryſtals above deſcribed were carefully freed, in the manner before mentioned, from the ad-

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adhering calcareous earth and ochre of iron, and then finely pulverized. They were then diſſolved in muriatic acid, aſſiſted by heat, alternately affuſing upon them the acid, and a large quantity of water. In this inſtance a trace of ſiliceous earth, though ſcarcely diſcernible, appeared.

b) The greateſt part of muriat of lead, generated in the proceſs, was depoſited in fine needles, even before the ſolution had completely grown cold. The ſuper-natant clear fluid was then poured off, reduced to a ſmaller volume by evaporation, and freed from the muriated lead, which ſtill ſeparated. The muriated metal, collected with care, and briſkly deſiccated, weighed 74½ grains. By diſſolving it in hot water, and ſteeping into the ſolution a poliſhed piece of iron, the lead precipitated upon this laſt in fine lamellæ, and in the metallic ſtate.

c) But in order to find more accurately what proportion this muriated lead might bear to pure oxyd of lead, I made the following experiment.

Two hundred grains of lead, cut into ſhreds, were diſſolved in 300 grains of nitric acid, diluted with 10 ounces of water, and, with the aſſiſtance of digeſtion, in a boiling heat. The ſolution was then divided into two parts.

α) Into one half I dropped muriatic acid, as long as it produced any turbidneſs; evaporating afterwards the mixture to the moſt perfect dryneſs of the reſidue. The muriat of lead here produced weighed 133 grains.

β) From the ſecond half of the nitric ſolution I precipitated the oxyd of lead by diſſolved cauſtic potaſh. This oxyd, when edulcorated and briſkly dried till it began to turn yellowiſh, amounted to 115 grains.

From this it followed that thoſe 74½ grains of muriated lead, obtained from 100 grains of the yellow molybdat of lead (*b*), are equal to 64,42 grains of pure *oxyd of lead.*

d) The concentrated muriatic ſolution of molybdena, which had a blue colour, was mixed with nitric acid, and lodged in a ſand-bath for farther evaporation. Being thus circumſtanced, it was again diveſted of its blue colour, and a yellow oxyd of molybdena ſeparated. But when the evaporation had been carried on to complete dryneſs, I collected and weighed the remaining lemon-yellow *oxyd of molybdena*; and found it amount to 34¼ grains.

Wherefore, *one hundred* parts of the pureſt cryſtals of the *yellow lead-ore*, from *Carinthia*, contain:

Oxyd of lead	64,42
Oxyd of molybdena . . .	34,25
	98,67

LXIV.

LXIV.

CHEMICAL EXAMINATION

OF THE

SULPHURET OF COPPER,

(*Vitreous Copper-ore. Kupferglanzerz*)

From SIBERIA.

AMONG the copper-ores, the firſt place belongs to the *grey*, or *vitreous Copper-ore*, it being the richeſt in copper, and containing, beſides its mineralizer, which is ſulphur, the feweſt foreign admixtures. Its purer varieties poſſeſs a degree of ſoftneſs, ſo that they admit of being in ſome manner cut with the knife; and on the recent cut they reſemble metallic lead in colour and luſtre.

This ore uſually occurs in compact maſſes; it is ſeldom cryſtallized. Of this latter ſort I poſſeſs ſome from *Poldice* and *Dolcoath*, in *Cornwall*, in *druſes* (groups of regular cryſtals) of minute white-grey, reſplendent, tetrahedral, truncated pyramids.

For the ſubject of my enquiry, I took the maſſive, compact, moderately-ſoft vitreous copper-ore, from the mine *Gumeſchefskoi*, on the river *Turja*, in the diſtrict of *Catharineburg*; where it is found in conſiderable large maſſes, which, in the *partings*, are inveſted with azure copper-ore, and fibrous malachites. It was freed from theſe previouſly to its being ſubjected to the following experiments.

A.

A.

a) Upon *two hundred* grains of the ore, coarſely powdered, moderately ſtrong nitric acid was affuſed, which attacked and diſſolved them with frothing and extrication of red vapours. The ſolution was clear, and the ſulphur alone in the ore was left behind, floating in the fluid, in grey, looſe, flocculi, without any other reſidue; which indicated that no antimony was preſent. The ſulphur collected on the filter was heated in a ſmall crucible to inflammation, and it burned with its peculiar odour, without any trace of arſenic; yet leaving a ſlight portion of oxyded iron and ſiliceous earth.

b) The ſolution, which had a pure blue colour, was treated firſt with muriat, and then with ſulphat of ſoda. But none of theſe, nor any other ſalt, rendered it turbid, or produced any other alteration; by which it appears, that this ore contains neither *ſilver* nor *lead*.

B.

a) To determine, with proper accuracy, the proportion of the conſtituent parts, I repeated the examination in the following manner. *Two hundred* grains of the powdered ore were combined and heated with muriatic acid, to the degree of boiling. But as this acid alone manifeſted no action on it, I added nitric acid gradually, by drops; which exerted a ſtrong attack in each inſtance. When the ſolution of the ore had been accompliſhed, I ſeparated the fluid from the ſulphur floating on the ſurface; and digeſted this laſt once more with a freſh quantity of muriatic acid, dropping into it ſome nitric acid; after which I collected it upon the filter. This ſulphur, waſhed and deſiccated, weighed 38½ grains, out of which, after its combuſtion, 1½ grain of *ſiliceous earth* remained; ſo that the true amount of *ſulphur* was 37 grains.

b) The ſolution exhibited a glaſs-green colour. I divided it into two parts. Into one half poliſhed iron was immerſed; upon which the *copper* precipitated of a dendritical form, and pure metallic brilliance. It weighed 78½ grains, when waſhed, and immediately deſiccated in a moderate temperature.

c) In order to aſcertain the proportion of iron contained in the ore, I combined the other half of the ſolution with cauſtic ammoniac added to exceſs of ſaturation. The precipitated iron remained behind, in the form of a ſubtle brown mud, which, collected on the filter, deſiccated and ignited, weighed three grains. But as the iron is contained in the mixture of the ore, not in this calciform ſtate, but in the reguline, which laſt is to the firſt in the proportion of 3 to 4, theſe 3 grains of oxyded iron give 2¼ of *metallic iron* to be added in the computation.

Therefore, *hundred* parts of the *Siberian vitreous copper-ore* conſiſt of:

Copper	B *b)*	78,50
Iron	*c)*	2,25
Sulphur	*a)*	18,50
Silex	*a)*	0,75
		100

C.

Copper-ores eminently belong to thoſe kinds, the component principles of which are but imperfectly determined by analyſis *in the dry way*. The reaſon of this is, partly, that the alkaline ſalts employed for the reduction, exert, during fuſion, as well as in the humid way, a very ſtrong ſolvent power on copper.

But although the reducing flux, compoſed of glaſs, borax, and charcoal-duſt, recommended by *Gellert*, *Tillet*, and others, inſtead of alkalis, is reckoned one of the beſt; yet I have always found the common *black-flux*, if employed in the following manner, the moſt effectual.

Two *docimaſtic centners* (each of 100 parts, conſidered for as many pounds), of the triturated ore were mixed with half a centner (or 50 parts), of charcoal-duſt, and properly roaſted until all the coal was conſumed *. I then blended it with $\frac{1}{4}$ centner of colophony and 6 centners of the black flux, covering the maſs in the aſſay-crucible with common ſalt, and expoſing it to a forge heat. After the coals were completely red, the blowing of the bellows was kept up for 20 minutes. The fuſion being accompliſhed, I found, under a well-fluxed ſcoria, 138 parts of a fine *red*, or *refined copper*; which is 69 *per cent*.

However regularly this aſſay in the *dry way* was performed, yet it produced 9$\frac{1}{2}$ *per cent*. leſs than the true proportion of the copper in the ore amounts to. The *humid way*, therefore, is, in every reſpect, the moſt certain to diſcover the true quantity of copper in any ore.

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* The roaſted-ore weighed 210 pounds.

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LXV.

CHEMICAL EXAMINATION

OF THE

VARIEGATED COPPER-ORE.

(Bunt-kupfererz. Purple Copper-Ore, by Kirwan.)

THE *variegated Copper-ore* is diſtinguiſhed in its external appearance from the *vitreous*, to which it is the neareſt a-kin, by its variegated colours, reſembling thoſe of tarniſhed ſteel; and, with regard to its conſtituent parts, it differs from it in containing leſs copper, but, on the contrary, more iron.

FIRST SECTION.

Variegated Copper-Ore from Hitterdahl.

THE variegated copper-ore occurring at *Hitterdahl*, in *Norway*, in lumpy maſſes, exhibits, on its recent fracture, a mixture of colours of light-blue, tin-white, and copper-red; which, however, by expoſure to air, gradually change into a more uniform ſteel-blue.

A.

One hundred grains of the pulverized ore were ſubjected to gentle digeſtion with nitric acid, whoſe action upon it was but moderate. From the reſidue, the ſulphur was driven out by combuſtion. This reſidue, when a ſecond time digeſted with nitric acid, diſſolved in it, leaving only a ſlight portion of a red oxyd of iron. On examining the

ſolution,

ſolution, firſt by common ſalt, and then by Glauber-ſalt, it continued limpid and unchanged.

B.

a) Upon *two hundred* grains of the powdered ore muriatic acid was affuſed, the mixture heated, and then combined in ſmall portions with nitric acid. The ſolution, which was thus performed, had a brown colour while concentrated; but as ſoon as it was diluted with water, it acquired a green. The remaining ~~ſulphur~~ was grey, tenacious, and ſpongy, and weighed 72 grains when dry. By ſlow combuſtion it left 35 grains, of which, after extraction by muriatic acid, five grains ſtill remained behind. Theſe loſt one grain more of ſulphur by burning, and the remaining four grains diſſolved entirely in muriatic acid. Whence the quantity of *ſulphur* amounted to 38 grains.

b) The muriatic ſolution was divided into *two* equal parts; and the *copper* was precipitated from one of them by means of iron. It amounted to 69½ grains.

c) The other half was ſuper-ſaturated with cauſtic ammoniac, and the oxyd of iron which fell down was collected. This, when moiſtened with linſeed-oil, and expoſed to a low red-heat, weighed 10 grains; which are equal to 7½ grains of *metallic*, or reguline *iron*.

Thus, in *one hundred* parts of this *variegated copper-ore* from *Norway* were found:

Copper . . .	B. *b*) . . .	69,50
Sulphur . . .	*a*) . . .	19
Iron	*c*) . . .	7,50
Oxygen . . .	. . . . .	4
		100

By

In ſupplying the deficiency in the ſum of weights of the copper, iron, and ſulphur, from the hundred, by putting *oxygen* in the account, I mean to characterize this laſt as a conſtant conſtituent part of the variegated copper-ore, producing in it thoſe variegated colours: in the ſame manner, as in ſteel, in copper-pyrites, and other metallic ſubſtances, the beginning of their oxydation is indicated by a ſimilar diverſity of colours.

In the laſt mentioned ſubſtances, however, the changeable colours are only owing to external cauſes; for which reaſon, they preſent themſelves only on the ſurface, when long expoſed to air. On the contrary, the variegated copper-ore is penetrated throughout its whole maſs by the oxydating principle. This correſponds with the deficiency of weight to make up the ſum of the fixed conſtituent parts of the ore here analyſed; whereas no ſuch loſs is obſervable in the vitreous copper-ore, treated and decompoſed by the ſame method. It is on this account alſo, that the action of the nitric acid is leſs ſtrong, and the diſengagement of nitrous gas is leſs copious, in the variegated than in the vitreous copper-ore.

SECOND SECTION.

Variegated Copper-Ore from Rudelſtadt.

THE native place of this variety of variegated copper-ore is the mine *Friederike Juliane*, at *Rudelſtadt*, in *Sileſia*, in which a rich vein has lately been opened, of beautiful native ſilver, imbedded in ponderous ſpar, and accompanied by pyramidal red ſilver-ore, along with cryſtallized white cobalt-ore (*Glanzkobalt*), that has raiſed the ardent wiſhes of the proprietors for its continuance.

A.

Two hundred grains of the powdered ore, having been twice extracted by means of nitric acid, left behind their ſulphureous ingredient, together with a quantity of red oxyd of iron. The ſolution was filtered, and tried by proper reagents for ſilver, lead, zinc, arſenic, and the like, and it afforded no indication of theſe, but only of copper and iron.

B.

a) *Two hundred* grains of this ore, in pure pieces, freed from interſperſed quarz, were triturated, and treated with muriatic acid, to which a little nitric acid was afterwards added, and the extraction continued in a moderate warmth. The colour of the filtered ſolution was a celadon, or blueiſh green, with a ſhade of grey. The reſidue, porous like ſponge, weighed at firſt 88 grains; but only 56 grains, after its ſulphur had been gently burned off. Theſe, digeſted in a low heat with muriatic acid, ſoon diſſolved, forming a brown fluid, and left ſix grains more of ſulphur behind. Hence, the *ſulphur* contained in thoſe 200 grains amounted to 38 grains.

b) Theſe ſolutions were mixed together, and divided into *two equal parts*. From one half I precipitated the *copper* in due manner by means of a poliſhed piece of iron, and obtained 58 grains.

c) The other half was treated with cauſtic ammoniac, until the oxyd of copper, precipitated in the beginning, again diſſolved. The oxyd of iron, thus obtained, when collected on the filter, waſhed and deſiccated, was moiſtened with linſeed-oil, and ignited in a covered crucible. It weighed 24 grains. Hence, as, upon an average, four parts of oxyded iron, attractible by the magnet, are to be eſtimated as equal to three parts of reguline iron, I reckon 18 grains of *metallic iron*, inſtead of theſe 24 grains.

Since, for the ſame reaſon as in the foregoing analyſis, the loſs of weight in the ſum of the fixed conſtituent parts muſt be taken for the *oxygen* combined with the ore, and which eſcaped in the proceſs; the conſtituent parts of the *Sileſian variegated copper-ore*, and their proportions in the *hundred*, will be:

Copper	B. *b*)	58
Iron	*c*)	18
Sulphur	*a*)	19
Oxygen		5
		100

C.

With a view of making an *aſſay in the dry way*, I roaſted two docimaſtic centners with half a centner of powdered charcoal. The roaſted ore, now weighing 206 ℔. was then mixed with half a centner of colophony, and ſix centners of black flux. In this ſtate it was put in a crucible, and covered with muriat of ſoda. When kept in fuſion during 20 minutes before the nozzle of the bellows, it yielded a fine button, weighing 96 lbs. of red, or refined copper; which is 48 *per cent.* and hence, 10 lbs. ſhort of what was obtained in the *humid way*, (B. *b*).

LXVI.

CHEMICAL EXAMINATION OF THE *SIBERIAN MALACHITES.*

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a) ONE *thouſand* grains of compact, reniform *Malachites*, from the *Turjin* mines, on the *Ural*, were reduced to powder, and heated to complete redneſs in a ſmall glaſs retort, connected with the pneumatic apparatus. Much carbonic acid gas was diſengaged in this proceſs, to the amount of 252 cubic inches, without reckoning that part which was abſorbed by the water of the apparatus. This gas was entirely abſorbed by lime water, at the ſame time that a proportionate quantity of carbonated or crude calcareous earth was produced In the intermediate ſmall receiver a moiſture collected, weighing 78 grains, which, upon trial, proved to be pure water.

b) The pulverulent reſidue taken out of the retort appeared of a black colour, and weighed 716 grains. To ſerve for the following experiments, it was divided into four parts, at 179 grains each; and hence correſponding to 250 grains of the rough malachites.

1.) *One hundred and ſeventy-nine* grains of *ignited malachites*, combined with three times its quantity of black flux, were put into an aſſay-crucible, without lining it, and covered with *muriated ſoda*. In this ſituation it was committed to the fire of the blaſt-furnace, and when the coals had become red-hot without the action of the bellows, it was kept melting for the ſpace of twenty minutes. After cooling, it was obſerved that, in the broken retort, the whole mixture, under the covering of common ſalt, had run into an uniform, compact, and opake maſs, of the bright red-colour of ordinary ſealing-wax, and that no metallic button had been formed.

It follows from this, that there was not carbon enough preſent to take up entirely the oxygen of the metallic oxyd. Therefore the copper has, by means of this ſmall remainder of oxygen ſtill united with it, been brought into the ſtate of red oxyd of copper; and, as ſuch, it has diffuſed itſelf uniformly through the alkaline ſalt.

2.) *Hundred* and *ſeventy-nine grains* of *ignited malachites* were mingled with three times their quantity of *black-flux*, and 1-10th of *powdered charcoal*. When fuſed in this ſtate, during 20 minutes, under a ſtratum of *common ſalt*, in an aſſay-crucible not lined in the inſide, they afforded a button of reguline copper, which had run well together, and weighed 136½ grains.

3.) Another 179 grains of *ignited malachites*, mixed with *thrice* as many grains of *black-flux*, and one fifth part of their weight of *colophony*, and likewiſed fuſed for 20 minutes, under a cover of muriat of ſoda, in a crucible not ſecured by lining, yielded a well-melted button of reguline copper, weighing 138 grains.

4.) The remaining 179 grains of *ignited malachites* were, like the preceding, melted during the time of 20 minutes, under a cover of *common ſalt*. But the aſſay-crucible had previouſly been lined with powdered charcoal, and the malachites mingled with an equal weight of *calcined borax*, with half its quantity of *white glaſs*, and 1-4th part of *colo-*

phony,

phony, or boiled turpentine. By this proceſs I obtained, indeed, a well-fuſed button of reguline copper; but with a conſiderable loſs, as it weighed only 105½ grains.

B.

In order to diſcover more accurately the conſtituent parts of malachites, I performed the following experiments.

a) 100 grains of malachites, reduced to powder by trituration, were diſſolved in nitric acid; which was effected without leaving any reſidue. The ſolution had a bright-blue-colour, and was ſaturated to exceſs with cauſtic ammoniac: but the precipitate produced was entirely, and without turbidneſs, re-diſſolved by the exceſs of the alkali. This ſhewed that the malachites here examined was perfectly free from iron, and ſimilar admixtures.

b) I combined *hundred* grains of triturated malachites with a ſufficient quantity of ſulphuric acid, previouſly diluted with five parts of water, and accurately weighed together with the veſſel. After the malachites had been wholly diſſolved, which was effected gradually, and with a moderately ſtrong efferveſcence, the loſs of weight, occaſioned by the *carbonic acid gas* that was extricated, was found to conſiſt of 18 grains.

c) *One hundred* grains of the ſame powdered malachites were ignited, at a moderate heat, in a covered crucible. The black reſidue had loſt 29½ grains in weight. If from theſe be ſubtracted 18 grains for the carbonic acid, the remaining 11½ grains of loſs will conſiſt of *water*.

Another

d) And laſtly, 100 grains, which had been diſſolved in dilute ſulphuric acid, and precipitated by zinc, yielded 58 grains of pure *copper*.

In conſequence of theſe experiments, the *Siberian malachites* conſiſts, in the *hundred*, of:

Copper	58
Carbonic acid	18
Oxygen	12,50
Water	11,50
	100

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LXVII.

CHEMICAL EXAMINATION
OF THE
BISMUTHIC SILVER-ORE,
From *Schapbach*, in the *Black-foreſt*,
In Suabia.

THE *Biſmuthic Silver-ore*, which occurs in the mine *Friederich-Chriſtians*, in the valley *Schapbach*, in the *Black-foreſt*, *(Schwarzwald)*, and for the firſt acquaintance with which we are indebted to Mr. *Selb**, Maſter of the mines at *Wolfach*, has been deſcribed, as to its external characters, by *Widenmann*† and *Emmerling*‡. This mineral deſerved a complete chemical inquiry ſo much the more, as even now ſeveral *Mineralogiſts* ~~ſtill ſeem to doubt of~~ the exiſtence of this peculiar ſpecies of ores.—For this reaſon, I publiſh here its analyſis, which to perform I was enabled by Mr. *Selb*, ſending me of this mineral the quantity neceſſary for the purpoſe.

Since this ore is very much concreted with the *grey quarz*, ſerving to it as a matrix; and ſince in moſt ſpecimens it can be conſidered as only diſſeminated in the quarz, I have employed for its analyſis merely ſuch pieces as are the leaſt mixed with quarz, and, at the ſame time, the moſt free from copper-pyrites and galena, which accompany this ore.

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* *Chemiſche Annalen*, 1793. I. Band. Seite. 10.

† *Handbuch der Mineralogie*, Leipzig, 1794, page 716.

‡ *Lehrbuch der Mineralogie*, II. Theil. *Gieſſen*, 1796. Seite 203.

A.

A.

Examination in the dry way.

a) If biſmuthic ſilver-ore, in ſmall fragments, be ignited upon charcoal before the blow-pipe, there ſoon tranſude metallic drops of eaſy fuſion; which *eliquate*[*] more perfectly on the addition of borax. The glaſs of borax acquires by them a yellow colour, reſembling that of amber (*Succinum*), but mixed with white, and in ſome places alſo with a copper-red. The metallic button exhibits variegated colours, and continues long in fuſion. It is brittle, and appears of a tin-white in the fracture.

b) When *three hundred grains* of this ore, previouſly triturated, had been expoſed to a red-heat, in a ſmall retort, lodged in ſand, they afforded,—beſides a ſlight quantity of aqueous moiſture, no more than 2½ grains of ſulphur; the pure yellow colour of which proved the total abſence of arſenic. On the powder of the ore, which coaleſced but moderately, ſome metallic drops were found incumbent. It was then roaſted in an open teſt, until no trace of ſulphureous ſmell could be obſerved. After this proceſs, it had an aſh-grey colour, appeared of a very looſe texture, and weighed 313 grains.

On being combined with 1½ ounce of black flux, and reduced in an aſſaying-crucible, under a layer of culinary ſalt, it ran into a tin white metallic button, which weighed 174 grains, would admit of being cut with a knife, and, though it had become malleable, yet was brittle, and fell aſunder after ſome blows of the hammer.

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[*] On the proceſs of *eliquation,* in general, ſee *Gren's Principles of Chemiſtry,* Lond. 1800. vol. II. page 301.—Tranſl.

This metallic bead, when refined by cupellation, under the muffle, afforded a button of *pure reguline ſilver*, weighing 33½ grains.

B.

Examination in the humid way.

a) Upon *three hundred* grains of this ore I poured three ounces of nitric acid, diluted with one ounce of water. A great part of it diſſolved in this menſtruum, even in the cold. The reſidue was afreſh combined with one ounce of the ſame acid, weakened with half an ounce of water, and digeſted in a gentle heat. Both ſolutions, thus obtained, were filtered, mixed, and together evaporated to a ſmaller volume; during which proceſs there ſeparated from the fluid ſome cryſtalline grains, conſiſting of nitrat of lead.

b) The concentrated ſolution had a greeniſh colour.— When afterwards diluted with juſt as much of water as was requiſite to re-diſſolve that cryſtalline ſediment, it was poured into a large quantity of water. This laſt immediately acquired a milky appearance, in a high degree, and depoſited a white precipitate, which weighed 44½ grains, when collected, lixiviated, and dried in the air, and proved, on farther examination, to be *oxyd of biſmuth*.

c) Into the liquor, that had been freed from this oxyd, and was entirely clear and colourleſs, I then dropped muriatic acid, as long as it was rendered turbid by it. The precipitate which then enſued, did not appear to be mere muriat of ſilver; for this reaſon, I digeſted it for ſome time with a moderately ſtrong nitric acid. A conſiderable portion of it was thus re-diſſolved, and left pure horn-ſilver behind; which, upon careful collection, and deſiccation in a briſk heat, weighed 46 grains. Thus, the portion of pure *ſilver* is determined at 34½ grains.

d) The nitric acid, that had been affuſed upon the precipitate obtained by the muriatic (*c*), yielded, by dilution with much water, 32 grains more of oxyded biſmuth; which, with the preceding 44½ (*b*), gave together 76½ grains.

In order to aſcertain the proportion of reguline biſmuth in this ore, I diſſolved 100 grains of biſmuth in nitric acid; and after having concentrated the ſolution by evaporation, I poured it into a large quantity of water. When of the precipitate, thus produced, nothing more would fall down, on adding more water, I collected it on the filter, waſhed it, and ſuffered it to dry perfectly in the air. It then weighed 88 grains. To the water, which had been ſeparated from it, muriatic acid was added by drops; whereby a new precipitate enſued, weighing 35 grains, after edulcoration and drying.

As, by the reſult of this comparative experiment, *one hundred* grains of *reguline* biſmuth have, upon the whole, given 123 grains of *oxyded* biſmuth; it follows, that the 76½ grains of biſmuthic oxyd, mentioned at (*d*), and obtained from 300 grains of the biſmuthic ſilver ore, contain 62¼ grains of *metallic*, or *reguline biſmuth*.

e) The remainder of the fluid was farther reduced by evaporation; and, in this proceſs, muriat of lead ſeparated from it in delicate, broad-ſtriated cryſtals. This liquor was then combined with ſuch a quantity of ſulphuric acid, as was requiſite to re-diſſolve thoſe cryſtals, and a ſecond time evaporated to a conſiſtence of pap. The precipitate, which thence enſued, was ſulphat of lead, weighing 19 grains, when duly collected, waſhed, and dried.

f) What ſtill remained of the ſolution, after its having been freed from the lead before contained in it, was ſaturated

rated with cauſtic ammoniac added in excefs. In this way a brown ferruginous precipitate was produced; which was rapidly attracted by the magnet, and weighed 14 grains, when, after previous deſiccation, it had been moiſtened with linſeed-oil, and well ignited.—For theſe we muſt reckon 10 grains of metallic iron.

g) The liquor, which had been ſuper-ſaturated with ammoniac, and which, by its blue colour, ſhewed that it held copper in ſolution, was next ſaturated to exceſs with ſulphuric acid. On immerſing then a piece of poliſhed iron into it, two grains of *copper* were depoſited.

h) The grey reſidue of the ore, that was left behind by the nitric acid (*a*), weighed 178 grains. But when its ſulphureous part had been deflagrated, in a crucible gently heated, it weighed only 140½ grains. This determines the portion of *ſulphur* at 37½ grains.

i) Theſe 140½ grains were digeſted with *three ounces* of muriatic acid, in a heat of ebullition; and this proceſs was repeated once more with 1½ ounce of the ſame acid. Theſe ſolutions, by means of evaporation, yielded till the end muriat of lead in tender ſpicular, and likewiſe in broad-ſtriated cryſtals; which, when again diſſolved in the requiſite quantity of boiling water, then combined with ſulphuric acid, and evaporated, yielded 89 grains of ſulphated lead. Thus the whole quantity of this ſulphat, including the 19 grains mentioned at (*e*), amounted to 108 grains; for which, according to comparative experiments, 76 grains of *reguline lead* muſt be put in the computation.

k) That portion of the ore examined, which ſtill remained after all the conſtituent parts before mentioned have been diſcovered, conſiſted merely of the *grey quarzoſe matrix*; the weight of which, in the ignited ſtate, amounted to 70 grains.

Therefore, thoſe *three hundred* grains of *biſmuthic ſilver-ore*, mentioned above, were decompoſed into:

Lead	*i)*	76
Biſmuth	*d)*	62,20
Silver	*c)*	34,50
Iron	*f)*	10
Copper	*g)*	2
Sulphur	*h)*	37,50
Quarzoſe matrix	*k)*	70
		292,20 grains

It follows from this ſtatement, that, excluſively of the *quarzoſe gangue*, the conſtituent parts of the *biſmuthic ſilver-ore alone* conſiſt, in the *hundred*, of:

Lead	33
Biſmuth	27
Silver	15
Iron	4,30
Copper	0,90
Sulphur	16,30
	96,50

LXVIII.

LXVIII.

CHEMICAL EXAMINATION

OF THE

ANTIMONIATED SILVER,

from Wolfach, in Suabia.

ANOTHER foſſil, which is found only in the mines worked in the principality of *Fürſtenberg*, is the *Antimoniated Silver*. It occurs there in the pit, called *Wenzelsgrube*, near *Alt-Wolfach*; and its external characters have alſo been deſcribed by *Widenmann*[*] and *Emmerling*[†], in their elementary Introductions to Mineralogy.

It has already been proved by *Bergmann*[‡], but more circumſtantially by *Selb*[§], that this mineral is a compound of *native ſilver* and *reguline antimony*.

Selb employed in his experiments that variety of antimoniated ſilver, which, in former times, has occurred more frequently in coarſe-granular detached pieces; and he found its proportion of ſilver to amount from 70 to 75 in the hundred. But the fine-granular variety, which is now dug, is conſiderably more rich in ſilver.

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[*] *Handbuch der Mineralogie*, 1794, page 684.

[†] *Lehrbuch der Mineralogie*, II. Theil. page 162.

[‡] Opuſc. Phys. et Chem. vol. II. page 416.

[§] *Magazin für die Bergbaukunde*, von *Lempe*, III. Theil. page 5.

FIRST SECTION.

Antimoniated Silver in ſine Grains.

A.

Examination in the dry Way.

a) A SMALL piece of antimoniated ſilver, when tried upon charcoal, with the aſſiſtance of the blow-pipe, ſoon entered into fuſion. The antimonial part volatilized in its uſual vaporous ſtate, and left the button of ſilver entirely pure behind. Neither of ſulphur nor of arſenic any trace appeared.

b) Twenty-five grains, mixed with four times their weight of lead, and ſubjected to cupellation, yielded a button of pure ſilver, weighing 21 grains.

B.

Examination in the humid way.

a) Nitric acid was poured upon *hundred* grains of antimoniated ſilver, freed from calcareous ſpar adhering to it, and pulverized as much as its toughneſs would admit. The acid ſhewed no conſiderable action in the cold. Therefore I ſubjected the whole to a digeſting heat, in which I kept it, until nitric acid, added afreſh, would not farther attack this powder. Upon this I diluted the mixture with water, ſeparated the reſidue, and precipitated the ſilver from the colourleſs ſolution, by means of copper. The *ſilver*, thus obtained, amounted to 83½ grains, when lixiviated and dried in a warm temperature.

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b) The reſidue exhibited a reddiſh-white colour, after being waſhed and deſiccated in the air, and weighed 25 grains. It ſoon diſſolved in the muriatic acid, with which it was digeſted; leaving behind it a ſmall portion of muriated ſilver, which, upon reduction, by means of ſoda, in the ſmall ſpoon, ſtill gave ½ grain of *ſilver*.

c) I poured the muriatic ſolution into a large quantity of water. By this management it was decompoſed, and let fall a white, tender precipitate; which, dried in a gentle heat, weighed 20½ grains. This precipitate, upon trial, proved to be an oxyd of antimony, perfectly reſembling *powder of algaroth* (oxyd of antimony by the muriatic acid). One part of it I re-diſſolved in muriatic acid; and the ſolution, when poured into water previouſly impregnated with ſulphuret of ammoniac, yielded golden ſulphur of antimony, of a pure orange colour. The remaining part gave, by reduction with tartar, a metallic button; which, on being blown off with the bellows, entirely evaporated, without leaving any reſidue.

Therefore, ſince, by the reſult of other comparative experiments *, 16 grains of reguline antimony may be reckoned for thoſe 20½ grains of the metallic oxyd (*c*), the conſtituent parts of the *fine-granular* variety of the *antimoniated ſilver* are in the following proportion:

Silver	84
Reguline *antimony* . . .	16
	100

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* See page 130 of this work.

SECOND SECTION.

Antimoniated Silver in coarſe Grains.

ONE *hundred* grains of the coarſe-granular variety of *antimoniated ſilver*, when decompoſed in the ſame manner as the preceding, yielded:

Silver	76
Reguline *antimony*	24
	100

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LXIX.

CHEMICAL EXAMINATION OF THE CRYSTALLIZED, BRIGHT, WHITE *COBALT-ORE*,

(Glanzkobalt),

From TUNABERG, in *Sweden*.

THE cryſtals of the *Bright*, *White Cobalt-ore*, which occurs at *Tunaberg*, in *Südermannland*, together with the copper-pyrites (*yellow copper-ore)*, are diſtinguiſhed by the ſtronger metallic luſtre of their external ſurfaces, which renders them leſs liable to decay, as well as by their ſize, of a rather uncommon magnitude *.

The colour of their ſurface and recent fracture is a tin-white paſſing into the grey; and the form of theſe cryſtals conſiſts, for the moſt part, in variations of the cube, with unequally truncated edges, and ſtriated lateral facets. The *ſtriæ*, or ſmall channels of each ſurface, are parallel to thoſe of the oppoſite one, but perpendicular to thoſe of the adjoining ſide. This remarkable direction of the *ſtriæ* has, till now, been found only in this cobaltic ore, and in ſome cubes of ſulphur-pyrites, ſtriated in the ſame manner. The fracture of theſe cryſtals is uneven, and exhibits a foliated texture.

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* One of theſe cryſtals, extremely beautiful and large, and detached from others, is in the poſſeſſion of M. *Mierotto*, Counſellor in the Eccleſiaſtical Department at Berlin; whoſe collection of minerals is ſo highly inſtructive with regard to the *Geognoſy* of the countries ſituated on the *Baltic ſea*. This cryſtal is 1½ inch long, of the ſame height, one inch broad, and weighs 4½ ounces.

I. *Experiments in the humid way.*

A.

One *hundred grains* of this cobalt-ore were digeſted with nitro-muriatic acid, in a boiling heat. The metal diſſolved but ſlowly, and in a ſmall quantity. As long as the ſolution was hot, it appeared of a dark emerald-green; but, upon cooling, it turned reddiſh-brown. No arſenic would depoſite from it. Hence, the above menſtruum did not ſeem likely to effect the decompoſition which I intended of the cobaltic ore.

B.

a) Hundred grains of rough white cobalt-ore, when gently digeſted with nitric acid, diſſolved in it gradually; however, leaving behind them 16½ grains of ſmall, white-grey, reſplendent globules, which conſiſted of arſenic, together with a little ſulphur. By boiling with water, this arſenical ingredient was diſſolved, and there remained 1½ grain behind; of which ½ grain of ſulphur deflagrated on a ſmall hot teſt. The remaining 1 grain was oxyd of cobalt.

b) The browniſh-red nitric ſolution was evaporated to a part, on a ſand bath. In this proceſs there ſtill ſeparated an oxyd of arſenic, in the form of a white cryſtalline incruſtation; which, collected after cooling, and by degrees lixiviated with a little water, weighed 30 grains after deſiccation.

tion. It again entirely diſſolved in the water with which it was boiled.

c) Both the ſolutions of the arſenical oxyd in water ſhewed exactly the ſame appearances which are exhibited by any other aqueous ſolution of arſenic. By combination with lime-water, they yielded *arſeniat of lime*; with ſulphuret of ammoniac they produced *yellow ſulphuret of arſenic* (orpiment), and the *green pigment* of *Scheele* with ammoniacal oxyd of copper.

d) When the nitric ſolution of cobalt would no longer depoſite any arſenic, I diluted it with water, and precipitated, by means of vegetable alkali, the oxyded cobalt; which, at firſt, had a peach-flower colour, and, towards the end, that of lilac. On diſſolving this laſt, precipitated in muriatic acid, and diluting the ſolution with water, the liquor acquired a roſe-red colour, and afforded the well-known ſympathetic ink prepared from cobalt.

Therefore, the conſtituent parts of the *cryſtallized, white cobalt-ore*, ſeparately produced in this analyſis, conſiſt, in the *hundred*, beſides the portion of cobalt itſelf, of 45 grains of arſenical oxyd, and ½ grain of ſulphur: but of any portion of iron no trace appeared.

However, as I had reaſon to ſuppoſe that the ingredient proportion of arſenic here ſtated might, perhaps, not be the true one, I endeavoured to aſcertain it more accurately in the dry way.

II. *Experiments in the dry Way.*

A.

a) *Four hundred* grains of white cobalt-ore, coarſely powdered, were heated to redneſs in a ſmall glaſs retort, connected with a receiver, and kept in the ſtate of ignition for ſome time. After cooling there appeared in the neck of the retort no more than *one* grain of ſublimed arſenic, together with a ſlight trace of ſulphur.

b) The contents of the retort were then introduced into a ſmall open matraſs, and once more ſtrongly ignited; but no ſublimation enſued.

c) Upon this, I mixed the cobalt with 1-4th part of its weight of powdered charcoal, and calcined it in a ſhallow open pot. At this inſtant the arſenic eſcaped in vapours; but ſlowly, and it coated metallic ſubſtances, that were held over the pot, with a thick white cruſt. The ſmell of this vapour reſembled that of garlic, only in very moderate degree; and it ceaſed to be emitted after the roaſting had been continued for two hours.

But, by this calcination, the cobalt was not yet entirely deprived of all portion of arſenic; for, when it had been diſſolved in nitric acid, and the ſolution concentrated by evaporation, there was ſtill ſome arſenic depoſited.

B.

a) For this reaſon, another *two hundred* grains of rough, white, cobalt-ore, previouſly triturated, were, in the firſt inſtance, mixed with 100 grains of charcoal-duſt, and calcined. This roaſting was twice repeated, mixing the ore each time with 50 grains of powdered charcoal; after which it no longer emitted any trace of exhaling arſenic. The cobaltic oxyd, which now, to appearance, had been entirely freed from arſenic, weighed 104 grains, and exhibited a black colour.

b) Theſe 104 grains were mingled with carbonat of potaſh and crude tartar, of each three drachms. The mixture, when introduced into a ſmall crucible, and covered with muriat of ſoda, was kept in the fire, before the nozzle of the bellows, during 20 minutes. The cobalt, thus reduced to the reguline ſtate, was found to weigh 75 grains. Its external ſurface had a finely knit, or interwoven appearance. But when I endeavoured to break it by the hammer, it proved to be hard, and ſomewhat tenacious. Its internal ſurface was partly porous; partly it exhibited a rough fracture, paſſing into the *hackly*, that is, preſenting ſharp points to the feel.

c) After theſe 75 grains of metallic cobalt had been pounded, they were roaſted, in a briſk fire, for two hours; upon which the calcined cobalt appeared again in the character of a black oxyd, with an increaſe of weight of 18 *per cent.*

Since it may be preſumed, with probability, that this cobaltic oxyd, which has been re-produced from the reguline cobalt revived at (*b*), contains oxygen in the ſame proportion with the oxyd prepared by roaſting the rough cobalt ore; and, as conſequently, thoſe 104 grains (*a*) of oxyded cobalt have contained 88 grains of pure reguline cobalt; it follows, that the conſtituent parts of this *white cobalt-ore*, from *Tunaberg*, are, in the *hundred*:

Reguline *cobalt* . . .	44
Sulphur	0,50
Reguline *arſenic* . . .	55,50
	100

LXX.

CHEMICAL EXAMINATION

OF THE

COBALTIC ORE OF MANGANESE,

From RENGERSDORF, in *Luſatia.*

THE foſſil that was the object of the preſent enquiry occurs near *Rengersdorf*, in *Upper-Lusatia*, in a ſtratum of quarz, which, on the *Heideberg*, comes up to the day. It has, till now, been conſidered as a *black hæmatitic iron-ſtone*[*], until the late Profeſſor *Leske* has introduced it as a *black cobalt-ore*[†]. However, as he declared to entertain a wiſh that this claſſification, which he founded partly on the external characters of this foſſil, partly on ſome previous experiments made with it[‡], might be farther examined by a chemical analyſis, it was by this declaration that M. *Westrumb* was induced to undertake this taſk.

From the appearances which this celebrated chemiſt obſerved on experimenting with this foſſil, it reſulted, that it contained *manganeſe*: but, on the other hand, he denied it to contain a portion of *cobalt*[§], which, however, *Leske* had ſuſpected in it.

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[*] Schwarzer, Glasköpfiger Eisenstein.

[†] Schwarzer Erdkobalt.

[‡] *Reiſe durch Saxen* von N. G. *Leſke*. Leipzig, 1785. Page 230—230.

[§] *Kleine Phys. Chem. Abhandlungen*, von *Westrumb*, 2*ter* Band, 2 Heft, 1788, page 183.

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My examination of this mineral ſubſtance, of which I have received a ſtock from M. *de Gersdorf*, the worthy proprietor of the eſtates of *Meſſersdorf* and *Rengersdorf*, where it is found, has convinced me that, beſides mangaueſe, it indeed contains cobalt: but it has, at the ſame time, ſhewn, that the preſence of cobalt is hid by the predominant portion of manganeſe combined with it, or, at leaſt, rendered unobſervable on the firſt inſpection of the foſſil.

A.

a) The rough foſſil, when treated upon charcoal, under a ſtream of air, continued for ſome time from the blow-pipe, fuſes into an apake, blueiſh ſcoria.

b) Phoſphoric ſalt produces with it, by the ſame treatment, a crimſon-red vitreous globule.

c) Borat of ſoda is tinged by it of a dark hyacinthine-red; which colour, on adding a ſlight portion of arſeniated ſoda, paſſes into a pale blue.

d) One *hundred* grains of this foſſil were firſt calcined in a gentle heat, and afterwards ignited during half an hour. The foſſil loſt thereby 17 grains in weight, and its blackiſh colour was changed to a dark aſh-grey. During this proceſs of roaſting, there could not be obſerved either ſmoke or ſmell; and the loſs conſiſted merely of *aqueous particles*.

B.

a) *Five hundred* grains of this foſſil, previouſly comminuted in the mortar, were digeſted with a moderately ſtrong muriatic acid. There eſcaped vapours of oxygenated muriatic acid. By continuing the digeſtion at the degree of ebullition, the mixture loſt its brown colour, and the fluid became green, leaving a white earthy reſidue behind. But, on diluting the ſolution with water, its green colour diſappeared, and the filtered liquor acquired a weak browniſh-red. The reſidue, ſeparated by filtration, weighed 206 grains, after ignition.

b) I then reduced the volume of the muriatic ſolution by evaporating it; during which proceſs *ſiliceous earth* was depoſited, weighing 10 grains, when collected on the filter and ignited. After this I ſaturated the ſolution with diſſolved cauſtic pot-aſh, added in exceſs, kept the mixture for ſome time in digeſtion, and filtered it. A muddy reſidue remained on the paper, the dirty light-brown colour of which rapidly turned black on expoſure to air.

c) The fluid ſeparated from this reſidue was neutralized with muriatic acid, and then combined with carbonat of pot-aſh. It depoſited *aluminous earth*, the quantity of which, after ignition, amounted to 12 grains.

d) The above black reſidue (*b*) was again diſſolved in muriatic acid, and thrown down by mild vegetable alkali. The precipitate appeared of a pale-reddiſh colour. When edulcorated and dried, I ſubjected it to ſtrong red-heat, for one hour, in a calcining pot. It returned from the fire of a greyiſh-brown hue, and weighed 178 grains.

e) I ſubjected theſe 178 grains, for ſome time, to digeſtion, in a boiling heat, with a moderately ſtrong nitric acid, diluting afterwards the ſolution with water, and filtering it. There remained a tender, black reſidue behind, which, upon edulcoration, drying, and ignition, weighed 80 grains, and was *oxyd of manganeſe*. In order to try it for iron, I again digeſted it with nitric acid; in which, on the addition of a little ſugar, it immediately diſſolved, without leaving iron, or any other reſidue. When again precipitated by means of carbonated pot-aſh, it fell down as a carbonated oxyd of manganeſe, of a white colour, verging into the iſabella yellow.

f) Hence the nitric ſolution ſtill contained 98 grains of the mentioned 178; but from the firſt there muſt be ſubtracted *one* grain for copper, diſcovered in the ſequel. By mild vegetable alkali, this re-diſſolved portion was again precipitated, of a pale colour of peach-flower; and this precipitate, as the following examinations of it have ſhewn, conſiſted of an accurate mixture of *oxyds of cobalt* and *manganeſe*.

g) The 206 grains, which remained on diſſolving the crude foſſil (*a*), were mixed with twice their weight of carbonated pot-aſh, and moderately ignited during two hours; after which they were covered with water, ſuper-ſaturated with muriatic acid, and evaporated to a gelatinous conſiſtence: and when the *ſiliceous earth* had been ſeparated, waſhed, and ignited, it was found to weigh 114 grains.

h) I then neutralized the remaining muriatic liquor with carbonat of pot-aſh, and combined it afterwards with oxalat of pot-aſh: but by this neither any precipitation nor turbidneſs has been effected. It was then combined with cauſtic ammoniac, which threw down *aluminous earth*, the quantity of which, after ignition, conſiſted of 90 grains. The ſtill remaining portion of the fluid continued clear on the addition of carbonated ſoda.

i) With a deſign to aſcertain the proportion of copper which enters into this foſſil, and the preſence of which has al-

already been obſerved in the previous experiments, I affuſed ſulphuric acid upon 500 grains of the rough foſſil, evaporated the fluid on a ſand-bath, ſoftened the inſpiſſated maſs with water, and immerſed, after filtration, a poliſhed plate of iron into the clear ſolution, which had acquired a pale roſe colour. The plate of iron became gradually incruſtated with a cupreous pellicle; which, when carefully collected, weighed no more than ½ grain; and thus one grain of *oxyd of copper* muſt be put in the computation.

Therefore, the *five hundred* grains of the foſſil here examined have been decompoſed into:

Oxyd of cobalt, mixed with *oxyd of magneſia*	B. *f*)		97
Mere *oxyd of manganeſe*	*e*)		80
Oxyd of copper	*i*)		1
Silex	*b*)	10	124
——	*g*)	114	
Alumine	*c*)	12	102
——	*h*)	90	
Water	A. *d*)		85
			489

C.

But, that the 97 grains mentioned at (B. *f*), and which were obtained in the carbonated ſtate, have really conſiſted of a mixture of oxyded cobalt and manganeſe, has been proved by the following experiments; the phenomena of which, at the ſame time, were compared with thoſe that are exhibited by the pure carbonated oxyd of manganeſe.

1. *a*) The colour of the above precipitate, in the carbonated ſtate, is the pale peach-flower red, and changes, on ignition, into the light-brown.

b) The

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b) The colour of the carbonated manganeſian oxyd is white, inclining to the iſabella-yellow; and that of ignited oxyd of manganeſe is black-brown.

2. *a*) If the ignited cobalto-manganeſian precipitate be digeſted with nitric acid, in a boiling heat, it leaves behind it a reſidue in the form of a ſubtle, black powder. If then carbonated pot-aſh be added to the filtered ſolution, which has a very pure, but dilute roſe-red colour, the diſſolved matter is thrown down by the alkali, of its former peach-flower red. The black reſidue, left unattacked by the nitric acid, when heated to redneſs, and digeſted in a heat of ebullition with a freſh portion of nitric acid, is rediſſolved for the greateſt part; and its diſſolved portion is again precipitated, of a pale red colour, by mild pot-aſh.

b) The ignited black-brown oxyd of manganeſe, by itſelf alone, is inſoluble in nitric acid; the acid that is boiled with it continues colourleſs, and lets nothing fall down on being ſaturated with an alkali.

3. *a*) If the above compound precipitate of cobalt and manganeſe be diſſolved in muriatic acid, and abundantly ſuperſaturated with carbonated ammoniac, the clear fluid which ſtands over the ſediment acquires, after ſome time, a dilute colour, reſembling that of the bloſſom of flax-weed.

b) The oxyd of manganeſe, on the contrary, when diſſolved in the ſame manner in muriatic acid, and precipitated by carbonat of ammoniac, added to exceſs of ſaturation, leaves the liquor ſtanding over the ſediment entirely colourleſs.

4. *a*) On adding the mentioned cobaltic precipitate of manganeſe to a neutral phoſphat, fuſed upon charcoal, the clear globule becomes tinged of a pure ſapphire-blue colour,

which continues unchanged by the outer, as well as by the inner flame of a candle, directed on it by the blow-pipe.

b) Oxyd of manganeſe, alone, produces with the phoſphoric ſalt a globule, which is devoid of all colour when urged by the interior flame, but acquires an amethyſtine red by the heat of the exterior.

5. *a.*) The combination of borax with the cobalto-manganeſian precipitate, upon the charcoal, before the blow-pipe, produces a glaſs globule of a dirty blueiſh colour, inclining to the blackiſh-grey. But as ſoon as a ſmall quantity of arſeniated ſoda is added, a pure ſapphire-blue colour appears.

b) Oxyd of manganeſe imparts to borax, when vitrifying upon the coal, a dark amethyſtine, and ſometimes a hyacinthine red colour. But the glaſs globule is immediately rendered colourleſs by the addition of arſeniat of ſoda.

6. *a*) When the precipitate compounded of cobalt and manganeſe is diſſolved in concentrated muriatic acid, the ſolution acquires a pale roſe colour, and it becomes graſs-green by heating. As the ſolution cools, its green colour diſappears, and the pale-red returns. If this ſolution be diluted with water, and employed inſtead of ink, the characters written with it become viſible, of a green colour, on warming the paper gently; but, upon cooling, that colour diſappears, and returns again when warmed; and ſo on, alternately. However, if the paper be heated too ſtrongly, the traces made on it acquire a brown and permanent colour.

b) The ſolution of oxyd of manganeſe alone, in concentrated muriatic acid, is, for the moſt part, entirely colourleſs: neither does it acquire any tinge by warming it. The traces written on paper with this ſolution, previouſly diluted with water, continue inviſible if the paper be expoſed to a gentle heat only: but by a ſtronger heat they turn brown, and loſe no more that colour, even after cooling.

D.

All theſe phenomena ſufficiently evince the preſence of cobalt in the above compound reddiſh precipitate. However, ſince the colours exhibited by this precipitate are, in all their changes, paler than thoſe which are produced by the oxyd of cobalt prepared from genuine cobalt-ores, it appears that the cobaltic is its ſmaller part. The mangancſe, on the contrary, conſtitutes the greater portion: and it ſeems that in this precipitate there obtains an intimate union between theſe two metals: for, although a great part of the manganeſe may be made ſeparable by ſtrong ignition, by which it is rendered inſoluble in nitric acid; yet I could not ſucceed in ſeparating entirely the remaining part of manganeſe from the ingredient cobalt, by repeated ignition and boiling in nitric acid.

It is on account of the manganeſe, ſo intimately combined with the cobalt, that neither the crude foſſil, nor the reddiſh precipitate ſeparated from it, imparts a true blue colour to vitrifying ſubſtances.

Yet, notwithſtanding this, the mentioned arſenical addition (5. *b*) affords a practicable means of rendering the ingredient portion of manganeſe ineffectual in tinging glaſſes. The reaſon of this is, that the manganeſe combines, and enters into a ſtate of complete ſaturation with the oxygen, which it ſeizes from the admixed arſeniat of ſoda. And as, in this ſituation, it does not, of its own accord, tinge vitrifying ſubſtances, it likewiſe no longer prevents the cobalt from imparting a pure ſapphire-blue colour; as is confirmed by the following experiments.

1. To *five* parts of that peach-flower coloured precipitate, previouſly diſſolved in muriatic acid, I added a ſolution of *two* parts of arſeniated ſoda, and effected a precipitation by means of carbonated ſoda. The precipitate, in this inſtance, acquired a lavender-blue, inſtead of a reddiſh colour; and, when added to a globule of borax, melted upon charcoal, it immediately coloured it of a pure ſapphire-blue.

2. a)	*Silex*	½ ounce of each.
	Calcined borax	
	Reddiſh cobalto-manganeſian precipitate	10 grains,

mixed and vitrified in a porcelain-pot, afforded a glaſs of a weak and cloudy amethyſt-colour.

b)	*Silex*	½ ounce of each,
	Calcined *borax*	
	Of the above *lavender-blue arſenical precipitate*	10 grains,

yielded a glaſs of a very pure ſapphire-blue colour, though not of that intenſity which an equal quantity of oxyded cobalt, prepared from the common good cobalt-ores, imparts to ſimilar glaſs-frits.

3. a)	*Silex*	½ ounce of each,
	Carbonated *pot-aſh*	
	Rough foſſil	2 drachms.

produced a ſmalt-blue glaſs, the violet colour of which too much inclined to a dirty brown-red.

b) *Silex*		½ ounce of each,
Carbonated *pot-aſh*		
Rough foſſil	2	drachms,
Arſeniat of ſoda	1	

gave a ſmalt-blue glaſs, of a pure violet colour.

4. It yet remained to examine what colour would be produced by the cobaltic portion of this compound metallic oxyd, in the encauſtic painting on porcelain. For this purpoſe, a part of the *lavender-blue arſenical precipitate*, prepared as before (No. 1.) was conveyed upon porcelain-veſſels, previouſly ignited, and then fuſed upon them. The painting returned from the furnace in every reſpect of a pure cobalt-colour, though rather weak.

Beſides theſe experiments, I performed a number of others with ſeveral variations, with a deſign of aſcertaining the proportion of cobalt in the ore here examined, as well as of ſeparating its oxyd of cobalt in a ſtate entirely free from all admixture of mangancſe. But, ſince the reſult would not anſwer my wiſhes, I abſtain from giving here an account of thoſe experiments; and am, at preſent, ſatisfied with having demonſtrated the preſence of *cobalt* in this *black, earthy ore of mangancſe* from *Rengersdorf.*

LXXI.

CHEMICAL EXAMINATION
OF THE
NATIVE SULPHAT OF COBALT.
(Kobaltvitriol)
From HERRENGRUND, *in Hungary.*

AT *Herrengrund*, near *Neuſobl* in *Hungary*, a vitrolic ſalt occurs, in pale roſe-red, tranſparent cryſtals, of a *ſtalactitical* form; which is conſidered by ſome as a *ſulphat of manganeſe*, but by others as a *ſulphat of cobalt.*

To remove this doubt, I undertook the following examination of this foſſil; and the reſult decided for the *latter* opinion.

Hundred grains of this metallic ſalt, when diſſolved in water, and precipitated by carbonat of pot-aſh, afforded ſeven grains of a looſe, pale-blueiſh precipitate, which turned black on expoſure to a red-heat. This precipitate, when fuſed upon charcoal, imparted to the glaſs-globule produced by the vitrification of a phoſphoric neutral ſalt, as well as to that which is obtained in the ſame manner from borax, a pure ſappharine blue colour. Its remaining part, that had not been employed for theſe experiments, yielded, upon ſolution in dilute muriatic acid, a ſympathetic ink; the traces of which directly aſſumed a yellowiſh-green colour on warming the paper, but diſappeared again as the paper cooled.

LXXII.

LXXII.

CHEMICAL EXAMINATION

OF THE

MINERAL SPRINGS AT IMNAU[*],

In SUABIA.

AMONG the many various *mineral waters* with which beneficent Nature has provided ſeveral parts of *Germany*, there are ſome which, by accident and good fortune, have acquired fame and credit; while others, on the contrary, though not leſs valuable, have either continued to be totally unknown, or have undeſervedly fallen into neglect and oblivion.

To theſe latter belong the *mineral-ſprings* at *Imnau*, a borough in *Suabia*, ſituated between *Tübingen* and *Rothweil*, in the eſtate *Haigerlôch*, which is the property of *Prince Hohenzollern-Sigmaringen*.

Although theſe ſprings had been famous as early as the times of *Taberna-montanus*, I have not yet ſeen of them any account earlier than that given by *Caſpar*[†]. But how little ſatisfactory his information can be with regard to the nature and conſtituent parts of the water, may be concluded even from the date of its publication; as, in general, at that time a well-founded chemical analyſis of water could not even be thought of.

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[*] *Chemiſche Annalen*, I. Band. page 1792,. 333.

[†] *Beſchreibung des Saeurbrunnens zu Imnau*, &c, durch Sam. *Caſpar*. Med. Dr. und Phyſicus zu *Sulz* am *Neckar*. Ulm. 1733, 8*vo*.

By the care of *Dr. Mezler*, phyſician to the Court of Hohenzollern-Sigmaringen, I obtained; of the mineral-water at Imnau, a quantity ſufficient for examination, in five well-ſtopped, and numbered bottles; the waters of which were taken from as many contiguous ſprings, flowing into one common reſervoir.

When the water arrived at Berlin it was found bright and clear; it frothed ſtrongly on being poured into glaſſes, and had an agreeable and ſtrong taſte of carbonic acid. From this deſcription only the water from the ſprings 4 and 5 ought to be excepted; becauſe, with reſpect to ſmell, as well as taſte, it ſeemed to be impregnated with ſulphurated hydrogen-gas.

Each of the waters contained in thoſe bottles I have firſt previouſly tried by means of *re-agents*. They were then ſubjected to analytical examination, in order to produce their conſtituent parts in a ſeparate ſtate.

A.

Examination by means of Re-agents.

I. *Tincture of Litmus.*

a) The *crude* water of all the five bottles, acquired by the tincture of litmus, a fine red colour.

b) When it had been *reduced* to one half *by boiling*, and filtered, it continued blue, on the addition of that tincture.

II. *Paper tinged with a decoction of Braſil-wood.*

a) The colour of the *crude* water changed the red colour of the paper to a violet.

b) *Boiled* water produced no change in the colour of that paper.

III. *Lime-water.*

On mixing equal parts of lime-water, and the water from each bottle ſeparately, the mixture was rendered cloudy and of a milk-white; but it rapidly became again clear.—However, by the addition of more lime-water, a quantity of carbonated lime fell down.

IV. *Concentrated Mineral Acids*

diſengaged from the water of each bottle numerous air-bubbles.

V. *Carbonat of Ammoniac, and Carbonat of Soda,*

produced a precipitate, which was thrown down entirely white, from the waters of the 1, 2, and 3 bottles; but that of the 4 and 5 bottles had an aſh-grey colour.

VI. *Cauſtic Ammoniac, and cauſtic Soda,*

yielded the ſame precipitates as at V. but in a leſs quantity,

VII. *Spirituous Tincture of Nut-galls.*

The water of the bottle, No. 1, ſuffered no change from it, except that it acquired a weak yellowiſh ſhade. But in the waters of the bottles marked 2, 3, 4, and 5, a purple precipitate was thrown down by this tincture, and the ſupernatant liquor acquired a violet colour, inclining to the green.

VIII. *Oxalic Acid*

immediately effected a copious precipitation.

IX. *Muriat of Barytes*

produced a precipitate in but a moderate quantity.

X. *Sulphat of Magneſia*

a) Threw down from the rough water, after 24 hours, a precipitate ſufficient to be obſervable.

b) But the boiled water, combined with the ſame ſalt, was not rendered turbid, and it continued clear.

XI. *Nitrat of Silver.*

The water of bottle 1 continued at firſt unaltered, but afterwards it became a little opaleſcent. Thoſe of the bottles No. 2 and 3 were altered very little; they, however, acquired a browniſh tinge. The waters of bottles 4 and 5 were immediately rendered blackiſh, and depoſited a black ſediment.

XII. *Acetate of Lead.*

In the waters of the bottles 1, 2, and 3, it produced a white, and in thoſe of the bottles 4 and 5 a dirty, light-brown ſediment.

XIII. *Running Mercury,*

preſerved in the waters of the bottles 1, 2, and 3, its bright luſtre; but it became tarniſhed of a blackiſh hue, when immerſed into the waters taken from the 4th and 5th bottles.

XIV. *Leaf of beaten Silver.*

Small pieces of this continued unchanged in the waters of the 1, 2, and 3 bottles; but in thoſe of the 4th and 5th they became tarniſhed, firſt of a gold, and then of a copper-colour.

B.

Analytical Examination.

As a detailed explanation of every ſeparate experiment would occaſion unneceſſary repetitions; to avoid theſe, I ſhall relate only, in a few words, the method which I purſued in theſe reſearches. To this I ſhall add, in a ſummary way, the conſtituent parts which I have diſcovered in the water of each particular ſpring, together with their proportion to each other.

I. *Examination of the gaſeous conſtituent part.*

It has already reſulted from the preceding reſearches, that this mineral water is richly impregnated with carbonic acid gas. To aſcertain the quantity of this gas, its extrication and collection were performed by means of the mercurial pneumatic apparatus.

On examining the waters taken from the bottles No. 4 and 5, the mercury in the cylinder became incruſtrated, at its upper ſurface with a brown pellicle, during the operation; but this did not take place with the waters of No. 1, 2, and 3.

The gas, that was diſengaged from the water of each bottle, was totally abſorbed by lime-water, and produced carbonat of lime. But in the common air, that occupied the ſpace left in the retort after the introduction of the mineral water, and which was driven over along with the carbonic acid gas, I could not diſcover any extraneous matter.

II. *Examination of the fixed conſtituent parts.*

a) *One hundred cubic inches* of water (reckoning the weight of water, filling the capacity of *one* cubic inch, equal to 290 grains of diſtilled water), from each ſpring ſeparately, were evaporated at a moderate temperature in a glaſs-diſh. The water

of the bottle No. 1, left 31¾ grains
. . . . 2, . 34½
. . . . 3, . 36¼
. . . . 4, . 39¾
. . . . 5, . 38

of a dry reſidue. That of No. 1 had a white, thoſe of No. 2 and 3 a light reddiſh-grey, and thoſe of No. 4 and 5 a reddiſh colour, of a little deeper caſt.

b) All theſe reſidues were firſt treated with alkohol, during 24 hours. The ardent ſpirit became imbued with a faint yellowiſh colour, and when ſeparated by filtration, and evaporated, it left behind it ſo ſlight a portion of a brown maſs, that its farther decompoſition was not well practicable. For this reaſon I collected it, by means of alkohol, into one maſs, from all the five evaporating-diſhes, and after having ſuffered the ſpirit again to exhale, I obtained a reſidue weighing four grains. When this reſidue had been re-diſſolved in very little alkohol, there remained $1\frac{1}{2}$ grain of *muriated ſoda*: and on combining the ſpirituous ſolution with ſulphuric acid, $1\frac{1}{2}$ grain of *reſinous matter* was ſeparated. But the ſulphuric ſolution yielded ſulphat of magneſia; for which one grain of *muriated magneſia* may be put in the computation.

c) After this extraction of the ſeveral reſidues, by means of ardent ſpirit, I affuſed water upon each of them ſeparately, and agitated the mixture ſeveral times. After 24 hours the aqueous extracts were, by means of the filter, ſeparated from the undiſſolved portion, and made to cryſtallize: firſt, with the aſſiſtance of a gentle heat, and then by ſpontaneous exhalation in the open air. Every one ſhot into priſmatic cryſtals, which conſiſted merely of *ſulphated magneſia*; with the exception of that which had been obtained from No. 1, and which alone was accompanied with a nearly unobſervable trace of *ſelenite*, or gypſum. Theſe ſaline lixivia left at laſt a brown moiſture behind, which hardly amounted to a few drops, and contained ſo ſmall a quantity of *gummous-extractive* matter, that it could not be eſtimated.

d) Upon the portion that remained undiſſolved in water, I poured alkohol, and afterwards I dropped nitro-muriatic acid into it, until all effervefcence and action of the acid ceaſed. On this proceſs a ſmall quantity of a muddy reſidue remained behind; which, when collected upon the filter, and ignited, left *ſiliceous earth* behind it.

All theſe ſolutions, previouſly filtered, were ſaturated with cauſtic ammoniac. By this combination, an hardly obſervable turbidneſs was produced in the ſolution of the reſidue left from the water of the bottle No. 1. But in thoſe of the other *four* reſidues a ferruginous precipitate enſued;

which was carefully collected upon the filter, then waſhed, dried, ignited, and weighed. This I diſſolved again in nitro-muriatic acid, in order to ſeparate a ſmall portion of *ſiliceous earth*; which ſtill has been mixed with it, and was afterwards collected, ignited, and weighed, for the purpoſe of aſcertaining the true weight of the iron, which the preceding precipitate had contained, by ſubtracting the weight of the ſilex from the whole weight of the former. After which, this portion of iron was reduced, in the computation, to a correſponding quantity of *carbonated oxyd of iron.*

e) After having thus ſeparated the ferruginous part, I reduced the ſolutions, in ſome degree, by evaporation; I combined them with a fourth part of their volume of alkohol, adding, then, concentrated ſulphuric acid by drops, which immediately threw down a quantity of ſelenite. I continued dropping in the acid, as long as any of this ſulphat of lime would fall down. The ſelenite was collected on the filter, and when it had been edulcorated with a mixture of water and alkohol, I again decompoſed it, by boiling with an aqueous ſolution of carbonated ſoda. The *carbonat of lime*, thus ſeparated, was waſhed, dried, and weighed.

f) To diſcover whether the fluid remaining from the ſeparated gypſum contained any magneſia, I evaporated it to ſome part, and combined it with carbonat of ſoda, at the degree of boiling heat: However, no precipitation took place.

According to the reſults of theſe inquiries, *one hundred* cubic inches of the waters of the *mineral ſprings* at *Imnau* contain:

I. *Water from the Bottle No.* 1.

Sulphat of magneſia, with a trace of *ſelenite*	5,75	grains
Muriat of ſoda	0,30	
Muriat of magneſia	0,20	
Carbonat of lime	25	
Silex	1	
Reſinous matter	0,30	
	32,55	grains

Carbonic acid gas, 104 cubic inches.

II. *Water from the Bottle No.* 2.

Sulphat of magneſia	5	grains
Muriat of ſoda	0,30	
Muriat of magneſia	0,20	
Carbonat of lime	27,75	
Carbonated oxyd of iron	0,75	
Silex	1	
Reſinous matter	0,30	
	35,30	grains

Carbonic acid gas, 105 cubic inches.

III. *Water from the Bottle No.* 3.

Sulphat of magneſia	5,50	grains
Muriat of ſoda	0,30	
Muriat of magneſia	0,20	
Carbonat of lime	28,25	
Carbonated oxyd of iron	1	
Silex	1	
Reſinous matter	0,30	
	36,55	grains

Carbonic acid gas, 104 cubic inches.

IV. *Water from the Bottle No. 4.*

Sulphat of magneſia	6	grains
Muriat of ſoda	0,30	
Muriat of magneſia	0,20	
Carbonat of lime	31	
Carbonated oxyd of iron	1,50	
Silex	1	
Reſinous matter	0,30	
	40,30	grains

Carbonic acid gas, 112 cubic inches.

V. *Water from the Bottle No. 5.*

Sulphat of magneſia	5,75	grains
Muriat of ſoda	0,30	
Muriat of magneſia	0,20	
Carbonat of lime	29,75	
Carbonated oxyd of iron	1,50	
Silex	1	
Reſinous matter	0,30	
	38,80	grains

Carbonic acid gas, 115 cubic inches.

It will be obſerved, that the ſum of the ſeparate conſtituent parts, in each of the above *five* computations, is a little greater than the weight of the entire dry reſidue, that has been at firſt obtained (B. No. 2. *a*.). This is to be accounted for by the water of cryſtallization, which enters into the ſulphat of magneſia.

C.

C.

In this ſummary ſtatement will be found wanting the *ſulphurated hydrogen gas*, ſuſpected before in the waters of the 4th and 5th bottle, or ſpring (page 581); the preſence of which, however, ſeemed to be indicated by their taſte and ſmell, as well as by the dark colour of the precipitate thrown down by acetated lead, and by the tarniſhing of the reguline mercury and ſilver-leaf (A. No. 13 and 14), immerſed into them.

However, ſince I have experienced in other inſtances, that, in mineral waters, theſe and ſimilar indications originate but rarely from real ſulphurated hydrogen gas, and that more frequently they ariſe from the admixture of putrefying organic matters; I entertained a doubt: whether that putrid vapour be an eſſential ingredient in the waters of the ſprings No. 4 and 5? Of this doubt I informed Dr. *Mezler*, requeſting him to examine this object on the ſpot. And it reſulted from the reſearches, which he made, that this ſmell, reſembling that of ſulphurated hydrogon gas, was owing merely to the putreſcent ſtate of a cement, which had been employed in the conſtruction of ſome pipes, through which it was found neceſſary to force the water of the *fourth* and *fifth* ſprings into their appropriate reſervoirs. This cauſe has been ſince removed; hence theſe ſprings are, at preſent, entirely free from all extraneous contamination. When the whole of the water had been pumped out of the reſervoirs, and, conſequently, when Dr. *Mezler* was enabled to examine water, that had recently iſſued from theſe ſprings, he found, neither by the taſte nor by the ſmell, the leaſt trace of that hepatic odour. Beſides this, he filled, under the ſurface of the water, four bottles; the *firſt* of which contained ſome clear pieces of white arſenic; the *ſecond*, ſome cryſtals of purified acetate of lead; the *third*, beaten leaf-ſilver; and the *fourth*, running mercury: ſtopping all theſe bottles cloſely. After 24 hours, the arſenic was found as white as before; the precipitate produced by the acetated lead was of a beautiful white; and the metallic luſtre of the ſilver and mercury was not in the leaſt impaired.

END.

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ERRATA.

Page	Line		read	
54	20	— *affect*	read	effect.
120	31	— 36		35
139	8	— 122		112
147	13	— $160\frac{5}{8}$		$160\frac{3}{8}$
278	22	— 2 3		$2\frac{2}{3}$
309	17	— 5—7		15. 1. 7.
342	8	— *1 grain.*		$1\frac{1}{4}$ grain.
354	29.30	— *would ſhoot*		would not ſhoot.
359	18	— *carbonic*		muriatic.
362	14	— 2,460		2,490
404	1	— *carbonated free ſoda*		cauſtic ſoda.
450	16	— 47 *lb.*		47 grains.
461	6	— *muriatic*		ſulphuric
475	8	— after *leucite*, read, whoſe earthy parts, like thoſe of lepidolite, are alſo ſilex and alumine, &c.		
479	12	— *ſulphuric*		ſulphureous.
500	24	— *muriatic*		ſulphuric.

219 transfer note (*) to page 218.
400 transfer note to —— 399.

Some other typographical errors, and miſtakes of leſs importance, are recommended to the Reader's kind indulgence.

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